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COMING EVENTS

Dec. 3, AIME Colorado Plateau Section, technical meeting, election of officers, WAAIME dinner-dance, Grand Junction, Colo.

Dec. 5, AIME Arizona Section annual meeting, Pioneer Hotel, Tucson, Ariz.

Dec. 5, AIME Boston Section, Richards Night. Topic: New Developments in Mineral Processing. Speaker: Robert M. Garrels, Professor of Mineralogy, Harvard University.

Dec. 6-8, 19th Electric Furnace Steel Conference, Penn-Sheraton Hotel, Pittsburgh, Pa.

Dec. 7, Symposium on Developments in Coal Mining Equipment, and Methods in Illinois; also, "The Stora Kaldo Process." Chicago Section, AIME.

Dec. 10, AIME Montana Section annual meeting, election of officers, and dinner-dance, Butte, Mont.

Dec. 12-14, National Conference on Water Pollution, Public Health Service, Washington, D. C.

Dec. 26-31, Annual meeting, American Association for the Advancement of Science, Boston.

Jan. 10-11, 1961, AIME Minnesota Section—University of Minnesota 22nd Annual Mining Symposium, Duluth, Minn. Headquarters, Hotel Duluth; technical sessions, Norshor Theater. Hotel reservations should be made at once; advance reservations for AIME Minnesota Section annual meeting January 9 ($3 for members, $5 for nonmembers) should also be made promptly.

Jan. 18, Third AIME Mechanical Working Conference, "Bar and Shaped Products," Penn-Sheraton Hotel, Pittsburgh, Pa.

Jan. 25-27, Instrumentation Symposium, for the Process Industries, Texas A & M College, College Station, Texas.

Feb. 22-25, International Symposium on Mining Research, sponsored by U.S. Bureau of Mines and Missouri School of Mines and Metallurgy, Rolla, Mo.

Feb. 26-Mar. 2, AIME Annual Meeting, Ambassador and Chase-Park Plaza Hotels, St. Louis.

Apr. 9-11, SEG 14th annual Midwestern meeting, Skirvin Hotel, Oklahoma City, Okla.

Apr. 9-13, ASME Oil and Gas Power Conference and Exhibit, Jung Hotel, New Orleans.

Apr. 10-11, ASME Maintenance and Plant Engineering Conference, Bancroft Hotel, Worcester, Mass.

Apr. 10-12, 44th National Open Hearth Steel Conference and Blast Furnace, Coke Oven, and Raw Materials Conference, Sheraton Hotel, Philadelphia.

Apr. 12-14, International Symposium on Agglomeration, sponsored by SME, SPE, and TMS of AIME, Sheraton Hotel, Philadelphia.

Apr. 23-26, ASME Metals Engineering Conference, Penn-Sheraton Hotel, Pittsburgh, Pa.

Apr. 24-25, Southwest Mineral Industry Conference, Las Vegas, Nev.

Apr. 26-27, AIME Technical Conference on High-Temperature Materials, Carter Hotel, Cleveland.

May 7-11, ASME—Engineering Institute of Canada Hydraulic Conference, Queen Elizabeth Hotel, Montreal.

May 15-18, Coal Show of the American Mining Congress, Cleveland. Suggestions for topics to be included in program should be sent to American Mining Congress, Ring Bldg., Washington 6, D. C.

Jun. 14-16, ASME Applied Mechanics Conference, Illinois Institute of Technology, Chicago.

Jun. 28-30, Joint Automatic Control Conference, University of Colorado, Boulder, Colo.

Aug. 28-Sept. 1, International Heat Transfer Conference, University of Colorado, Boulder, Colo.

Sept. 17-20, Commemoration of the 50th Anniversary of Froth Flotation in the U.S.A., sponsored by AIME: Society of Mining Engineers' Mineral Beneficiation Division, Cosmopolitan Hotel, Denver.

MINING engineering

VOL. 12 NO. 12 DECEMBER 1960

COVER *Artist Herb McClure joins the Staff of* MINING ENGINEERING *in wishing all a very Merry Christmas and best wishes for the coming New Year.*

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1260 **A Portrait of Chuqui as a Young Mine** • *T. D. Sawyer*

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COVER ART

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PERSONNEL

THESE items are listings of the Engineering Societies Personnel Service Inc. This Service, which cooperates with the national societies of Chemical; Civil; Electrical; Mechanical; Mining, Metallurgical, Petroleum Engineers, is available to all engineers, members and nonmembers, and is operated on a nonprofit basis. If you are interested in any of these listings, and are not registered, you may apply by letter or resume and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee of 60 pct of the first month's salary if a nonmember, or 50 pct if a member. Also, that you will agree to sign our placement fee agreement which will be mailed to you immediately, by our office, after receiving your application. In sending applications be sure to list the key and job number. When making application for a position, include 8¢ in stamps for forwarding application to the employer and for returning when possible. A weekly bulletin of engineering positions open is available at a subscription rate of $4.50 per quarter or $14 per annum, payable in advance. Local offices of the Personnel Service are at 8 W. 40 St., **New York 18;** 57 Post St., **San Francisco;** 29 E. Madison St., **Chicago, 1.**

In addition to the listings below, ESPS maintains a more complete file of general engineering positions and men available. Contact nearest ESPS office, listed above.

MEN AVAILABLE

Mining Engineer, 32, married. Experienced in planning, ventilation, and engineering supervision to position of chief mine engineer. Also experienced in production of track, trackless, and open cut mining of gold, base metals, and uranium to position of assistant mine superintendent. Prefer North American location. M-570.

Production Superintendent, B.S. in geology. Two years experience as underground metal producer; mucker, miner, mining engineer; five years with present employer engaged in large open pit operations; assistant mine superintendent, dredging superintendent, production superintendent, staff engineer. Exceptional record in costs, supervision, production, report writing, management. West or South. M-571.

Mine Superintendent-Plant Superintendent, E.M. degree. Ten years experience underground hard rock mine, plant supervision, and engineering. Background includes production planning, forecasting, and scheduling; project engineering; operations and engineering surveys; mine safety and legal compliance; equipment installation and maintenance; supervision; training. Age 34, married, professional engineer, Pennsylvania. Will relocate in U.S. M-572.

Mining Engineer-Geologist. Eight years experience in Central and South America with gold, base metals, and manganese as engineer, geologist, and manager. Speak Spanish and Portuguese. Prefer Latin America. M-573.

Project Engineer and Cost Estimator, age 38. Experienced in project planning, plant layout, evolving flow sheets, beneficiation plant layouts (including crushing, magnetic roasting, magnetic concentration, and pelletizing), materials handling, and estimating capital and operating costs for economic evaluations of low-grade iron ore deposits. Also experienced in design and estimating blast furnaces and auxiliary facilities, sintering plants, sludge recovery systems, and steel plant facilities. Location and salary open. M-574.

Mining Engineer, post-graduate, Dutch, age 33, married, no children. Two years underground copper and tin mining in South America; four and a half years placer and open pit mining and milling of heavy minerals in Congo. Desires responsible position. M-575.

Geophysicist-Geologist, registered professional engineer, BSc. E. and MASc. degrees, Canadian, married, no family. Wide experience in geological and geophysical mining exploration. Foreign operations preferred. M-576.

Manager (Mfg., Adm., Min.), graduate Columbia University, liberal arts and mining engineering, age 44. Experienced in design and construction of mines and mine plants, processing equipment; operation of manufacturing plants in mineral and chemical processing, including fertilizers; management of integrated divisional facilities, including all lines and related staff functions. U.S. or foreign. M-2016-Chicago.

Manager for design, construction and operation of chemical-metallurgical plants including material handling. Graduate engineer with 18 years experience. Familiar with processes used for production of most basic chemicals and metallic and nonmetallic minerals. U.S. M-2017-Chicago.

Economic Geologist, Ph.D. in geology, age 31. Seven years varied background in metals, nonmetals including petroleum and mineral economics. Industrial, academic, and governmental experience in U.S. and Canada. Have publications; presently employed. Salary and location open. M-2018-Chicago.

Mine Superintendent or Chief Mining Engineer, B.S. in geology, age 43. Fifteen years experience metal mining. Mine superintendent of 90,000 ton-per-month operation. Chief engineer with staff of 10 to 14 engineers. Familiar all phases underground metal mining, engineering, and production. Some pit experience. Professional engineering license. M-2019-Chicago.

Geologist, B.S. in geology, age 28. One year graduate work in photogeology; one year geologist for iron mining company; three years operator and computor for oil company. Experience includes drilling and geophysical programs, surveying, supervision of field and office crews. U.S. or foreign. M-2020-Chicago.

Mine or Mill Superintendent, mining engineer, 46. Over 20 years experience including sinter, gravity, flotation of manganese, iron, copper, tungsten plus metallurgical design, chemical process for operation, engineering, producers. $9600 up. Any location. Home: California. Se-1857.

Mine and Mill Engineer, mining engineer, plus management, 44. Twenty years experience staff, manager, assistant, chief engineer, engineer—large phosphate, sulphur, acid, fertilizer operation. Responsible for property, transport, warehouse, purchase, accounting for production, ship, service. For beneficiation, production, equipage, labor; for surface and underground, planning and operation. $12,000 up. Any location. Home: southeastern U.S. Se-1872.

Mine and Mill Superintendent, mining engineer, 31. Six years experience, including one year engineering for metals, mine, and mill; one year gypsum layouts and survey; one year open pit iron stripping, track and road layout, reserves; two years military building, survey, supervision, and steel design. $9100. Prefer Northwest or West. U.S. Home: Canada. Se-1846.

Mining Superintendent, mining engineer, 38. Twelve years varied mining experience in geology, engineering, production, planning, and supervision of mining operations. Experienced in mechanized as well as regular mining operations (emphasis on room and pillar, shrinkage, and open stoping). Good cost, production, and safety records. Handle reports and correspondence with facility. $9,600 to $12,000. Prefer Mediterranean area, U.S. Home: Utah. Se-1818.

Mine Manager, Superintendent, mining engineer, 41. Ten years experience; six years limestone, talc, copper in quarry, open pit, and underground, plus four years sales and service of explosives (drill and blast practice). $9000. Any location. Home: California. Se-1817.

Manager, 53. Twenty-five years experience including complete charge of lode gold operation, power plants, shops, camps, mines, and mills; underground design, construction and operation of mines and mills, railway system (gold, lead, zinc, copper). $12,000. Prefer Latin American, U.S., Orient. Home: California. Se-1790.

Chief Mining Engineer, MinE degree, 40. Fifteen years experience in highly mechanized open pit metal mining, mostly in engineering, with operating, construction, and exploration experience. Some underground experience. Available December 1. Salary open. Any location. Home: California. Se-1718.

Mine Engineer, Geologist, degree in geology, 36. Six years experience as mine engineer and geologist. Surface exploration, geophysical, geochemical methods, diamond drilling, areal geologic mapping. Property examination and evaluation. Metallics and nonmetallics. $8400. California or western U.S. Home: California. Se-1650.

Mine Superintendent, geological engineer, 40. Twelve years experience metal mining and exploration (geologic mapping, sampling, mine engineer-surveyor, underground supervision, contract mining, property management, and project engineer). Good experience on report writing. $9,600 to $12,000. Prefer Southwest, West. Home: Pacific Northwest. Se-1640.

Superintendent, Geologist, degrees in geology and mining engineering, 68. Forty years experience in charge of mining, exploration in domestic and foreign countries; precious and base metals, development and evaluation. $5000. Any location. Home: California. Se-1616.

Superintendent, Manager, mining engineer, 60. Many years experience managing operations, drilling, analyzing applications for permits to sell and issue stock, supervise development, design, estimators for mining

(Continued on page 1206)

MINING GEOLOGIST, Canadian, B.Sc., age 32, married. Experience 4 years field exploration, 5 years mining, base metals. Familiar with all phases from exploration to production. Holding senior staff position. Desires challenging employment in mineral exploration or mining. Write to Box 60ME13, MINING ENGINEERING, 29 W. 39th St., New York 18, N. Y.

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PERSONNEL

(*Continued from page 1202*)

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Mine Manager, Superintendent, 47. Twenty-six years experience in engineering, supervisory, and administrative positions. Excellent labor relations both in U.S. and 12 years in Latin America. Experience in most underground mining methods and some open pit. Salary open. Mexico, southwestern U.S. Se-192.

POSITIONS OPEN

Geologist with either geological engineering degree with a strong major or experience in mining, or a mining engineering degree with strong major or experience in geology. Prefer applicant with approximately five years experience. Work will cover geological and mining engineering extending from geological reconnaissance on through to complete development of mineral properties. Salary open. New York state. W9773.

Geophysicist or Geologist, with gravity and magnetometer survey experience for ground water project. Salary open. Foreign, Middle East. F9770.

Assistant Mining Engineer, technical background, with experience in drafting, mapping, and surveying as related to coal mining operation. Recent graduate would be considered. $6000 year. South. W9738.

Geological Mining Engineer, geologist or mining engineering graduate, with at least five years' field experience covering core drilling, analysis, estimates, etc. in iron ore open pit mining. Spanish desirable. $9,600 to $12,000 year. South America. F9724.

Mine Engineers for open pit mine, using draglines, followed by hydraulic transportation. a) *Head of Engineering* Dept. to coordinate mining operations with service departments. b) *Maintenance Engineer* for maintenance and mines utility work. South. W9721.

Mill Superintendent who has had experience with large-scale operation. Pennsylvania. W9696.

Assistant Mine Manager for fluorspar mine, graduate mining engineer, about 40, familiar with mining and milling, flotation, medium-size mill. Must know shaft sinking, stoping etc. Salary open. Newfoundland. F9275.

Assistant Mine Superintendent, with Latin American experience in underground mining, able to speak Spanish. $7200 per year plus two months' additional pay per year for benefits. Transportation paid for employe, wife, and children up to 12 years of age, married housing available. For gold mine in South America. Sj-5652.

Warehouse Manager, Buyer, with knowledge of requirements for re-opening mine. Setting up inventories, accounts, supplies, and equipment. Salary open. Housing available; schools for children. Nevada. Sj-5623.

Mine Manager, mining engineer or metallurgical engineer, over 30, at least five years experience with mine operation and management (nonmetallics). Must speak fluent Spanish, prefer Mexican citizen, will consider U.S. citizen who has worked in Mexico. Salary open. Mexico. Sj-5622.

Mine Engineer, mining engineering degree, prefer under 50, experienced in gold dredging or placer operation, capable of becoming manager of property. For operation including six dredges. Spanish helpful. Housing furnished. Two-year contract. Colombia, S. A. $3400 to start. Sj-5650.

Mine engineer, mining engineering degree, 28 to 35, five to ten years experience including underground work, preferably in western mines. Coal mine experience desirable, able to carry out general mining engineering, supervise men, plan and administer. Design, survey, and construction supervision for above and underground pumping and milling plants handling gilsonite ore. Will also serve as safety engineer. Under chief mine engineer and mine superintendent. Start $7200 to $8400, depending on qualifications, plus fringe benefits. West. Sj-5618-R.

Mine, Mill Superintendent, thoroughly capable man with recent experience operating mine and mill. Able to carry 100-man operation with two American assistants from development state through full operational stage. Must be able to speak Spanish. Family quarters approximately one hour from property. For operating company. $12,000. Mexico. Sj-5616.

General Superintendent, competent man, analytical in engineering, physically fit, and speaking knowledge of Spanish necessary. For 50 tpd Pb-Zn-Ag operation, 150 Spanish-speaking men. $6600 to $7200, plus furnished house, fuel, and electricity. Single status required for four to six months. 5000 ft; climate pleasant and healthful. Two-year contract. Central America. Sj-5613-R.

Mining Engineer, graduate, under 50. Should be junior or up to chief and must have open pit experience. For open pit and strip iron ore operation. Should be familiar with several million ton bulk material handling involving mining equipment, trucks, conveyors, and ship-loading equipment. Housing available. 2500 ft altitude; for a producer. Two-year contract. $6000 to $600 up, depending on experience, plus extensive other compensation. Peru, S. A. Sj-5605-R.

Geological Assistant, geologist, young (two needed). One for property development activity and one for exploratory work. Should be capable of conducting, under supervision, exploratory surveys, mapping, drillhole layout, sampling programs, and able to handle and work with native crews. For 25-man geological team. Established community on property; single status and subsistence for exploratory work. $7200 to $400. Caribbean area. Sj-5587.

Soils Laboratory Supervisor, must know triaxial sheer tests; also something about plastic and water limits, water content, density, consolidation, compaction tests, moisture adsorption and classification and concrete dam installations. Should be capable of administering complete program from start to finish manned by native field personnel and lab assistants. Single status; temporary, four to five months. $850 per month, plus housing. Africa. Sj-5583.

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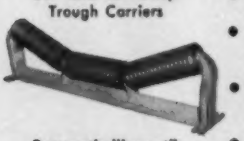

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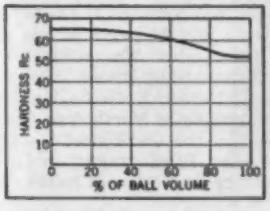

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A Checklist for the Organization, Operation and Evaluation of a Company Library, compiled by Eva Lou Fisher, *Special Libraries Assn.*, 31 E. 10th St., New York 3, N.Y., 64 pp., $2, 1960—This compilation by the former chief librarian of the Missiles and Space Div., Lockheed Aircraft Corp., provides answers to many problems confronting management, research, technical, and administrative personnel, as well as library administrators who must start a new library or evaluate one already in operation. Part I presents general problems of administration and management, such as how to determine the types of material to purchase. Part II deals with specific problems such as acquisitions and budget. Part III recommends a minimum plan.

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Correction

On page 1048 of the October issue the three volumes of the U.S. Bureau of Mines **Minerals Yearbook** were incorrectly listed as **1959.** These are the **1958** volumes.

Vibrations from Blasting Rock by L. Don Leet, *Harvard University Press*, Cambridge, Mass., 134 pp., $4.75, 1960—The author's purpose is to compile in brief but useful detail the most important factors concerning the nature and effect of vibrations generated by explosives. He discusses explosives and blasting caps, rocks and their rupture by blasting, the elastic-wave patterns of vibrations, and effects on neighboring structures of energy waves generated by explosions. • • •

Using Centrifugal Pumps by E. Allen, *Oxford University Press*, 246 pp., $4.80, 1960—In particular, this book is addressed to the operating and maintenance staff responsible for the efficient running and daily care of pumps, their installation and emergency repair. The author reviews fundamental principles and explains pump characteristics. Numerous examples are given of methods of correctly chosing type and capacity for both permanent and emergency needs. • • •

Index to Volume I of GeoScience Abstracts, *American Geological Institute*, 2101 Constitution Ave., N.W., Washington 25, D.C., 95 pp., $3, 1960—This supplement to the first year's issue of the journal contains 71 pages of subject index and 24 pages of cumulative author index. The subject headings are essentially those used in the indexes of the U.S. Geological Survey **Bibliography of North American Geology** and the Geological Society of America **Bibliography and Index of Geology Exclusive of North America.** • • •

The How and Why Wonder Book of Rocks and Minerals by Nelson W. Hyler, illustrated by Kenyon Shannon, *Wonder Books Inc.*, 1107 Broadway, New York 10, N. Y., 48 pp., 50¢, 1960.—This little book arrived in our office just in time for us to call it to your attention as a worth-while Christmas offering for any youngsters from 7 to 12 who have expressed curiosity about rocks and minerals. The simple text and many clear, colorful, drawings answer such questions as: What is a rock? What is an active volcano? Does the earth wear out? How can you tell how hard a rock or mineral is? There is a section on how to start a rock and mineral collection and an identification chart of major specimens. The book is part of a series designed to introduce the fascinating world of science to children in the middle grades.

Russian Journals Available

These journals in the fields of geology, geophysics, mineralogy, mining, and beneficiation are currently received by the Engineering Societies Library.

Akademiya Nauk, SSR, Izvestiya. Seriya Geofizicheskaya, 1957 to date. (Academy of Sciences, USSR, Bulletin. Geophysics Series)
Akademiya Nauk, SSR, Izvestiya. Seriya Geologicheskaya, 1957 to date. (Academy of Sciences, USSR, Bulletin. Geological Series)
Geokhimiya, 1959 to date. (Geochemistry)
Geologiya Nefti i Gaza, 1958 to date. (Geology of Petroleum and Gas)
Geologiya Rudnik Mestoroshdeniy, 1959 to date. (Geology of Ore Deposits)
Gorniy Zhurnal, 1957 to date. (Mining Journal)
Moscow. Gorniy Institut. Nauchnie Trudy, 1955 to date. (Moscow. Mining Institute, Scientific Papers)
Razvedka i Okrana Nedr, 1957 to date. (Location and Conservation of Mineral Resources)
Sovetskaya Geologiya, 1958 to date. (Soviet Geology)
Ugol, 1958 to date. (Coal)
Vsesoyuznoe Mineralogicheskoe Obshchestvo. Zapiski, 1958 to date. (All-Union Mineralogical Society. Memoirs)

Information on translation and/or photoprint and microfilm copies of articles from these journals can be obtained by writing to Ralph H. Phelps, Director, Engineering Societies Library, 29 W. 39th St., New York 18, N.Y.

Decisions Under Uncertainty; Drilling Decisions by Oil and Gas Operators, by C. Jackson Grayson, Jr., *Division of Research, Harvard Business School*, Soldiers Field, Boston 63, Mass., 402 pp. $6, 1960—This book considers problems in drilling for gas and oil—to drill or not to drill—and how business men make these

drilling decisions. It also explores the possibilities of applying mathematical theories to such decisions. The methods suggested for this purpose are clear and simple, requiring only a working knowledge of arithmetic and high school algebra. • • •

Physical Chemistry of Surfaces by Arthur W. Adamson, *Interscience Publishers Inc.*, 250 5th Ave., New York 1, N. Y., 629 pp., $12.75, 1960—This book is intended for graduate students in surface chemistry and for professional chemists in relating their basic chemistry to recent developments in surface chemistry. The treatment of capillarity in Chap. 1 includes tabular solutions to the Laplace equation in surface tensions measurements. The surface physical chemistry of solutions follows, including Gibbs monolayers as an introduction to spread films. There are discussions of charged films, electrical aspects of surface chemistry, and the nature of solid surfaces, including treatment of contact angle and nucleation phenomena. The topics of friction and lubrication, flotation and detergency, emulsions and foams are covered, as are chemisorption and catalysis. There is a concluding chapter on adsorption. • • •

Winning Coal by John Sinclair, *Sir Isaac Pitman & Sons Ltd.*, Pitman House, Parker St., Kingsway, London W.C. 2, England, 406 pp. approx. $8.40 (£3), 1960—Written for those preparing for British professional degrees and technical certificates by a specialist in mechanized mining. this book considers all methods of coal production at the face. An opening survey of open cast production is followed by concise treatment of the older hand-worked methods. The next five chapters deal in detail with methods of mechanized mining, including the panel and block systems in room-and-pillar mining, coal cutters, loaders, continuous miners, and cyclic and noncyclic longwall mechanization. The last two chapters deal with the use of explosives and substitutes such as cardox, hydrox, and compressed air. • • •

Engineering Economy by William L. Morris, *Richard D. Irwin Inc.*, Homewood, Ill., 506 pp., $10.50, 1960—Basically a textbook, this volume presents engineering economy within the larger context of the analysis of management decisions. In so doing it brings in ideas from operations research, management science, and decision theory. Sections on economics, accounting, and the probability theory are included to refresh undergraduate memories. They are also a big help to the engineer or manager who invests in this book long after his undergraduate days are over. • • •

(Continued on page 1210)

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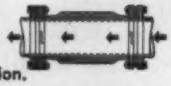

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BOOKS

(*Continued from page 1209*)

Nuclear Congress

Notice:

At the Nuclear Congress, held in New York City, April 4 to 7, 62 papers were presented as part of the *streamlined* technical program. Most of the papers deal with application and technical utilization of nuclear materials.

Of the 28 engineering and scientific organizations supporting the 1960 Nuclear Congress, the AIME participated as a sponsor.

These papers may be ordered at 50¢ per paper, or $20 for the set. Address all orders and inquiries for list of papers to the 1960 Nuclear Congress, 29 W. 39th St., New York 18, N. Y.

U.S. BUREAU OF MINES

Copies sold through:

Superintendent of Documents Government Printing Office Washington 25, D. C.

RI 5516 Tungsten Deposits of Yuma, Maricopa, Pinal, and Graham Counties, Ariz., 45¢.

IC 7914 Sinking No. 3 Shaft at Westvaco Trona Mine, Intermountain Chemical Co., Sweetwater County, Wyo., 25¢.

IC 7922 Uranium-Mining Practices and Costs at Ten Salt Wash Lease Operations of Union Carbide Nuclear Co., 60¢.

IC 7948 Coal Chemicals for World Markets, 35¢.

IC 7938 Open-Pit Copper Mining Methods at New Cornelia Branch, Phelps Dodge Corp., Prima County, Ariz., 50¢.

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IC 7912 Milling and Processing Tungsten. 60¢.

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RI 5550 Recovering Iron Concentrates From the Pea Ridge Deposit, Central Missouri.

RI 5559 Gasification of Pulverized Coal at Atmospheric Pressure: Discussion of Pilot-Plant Development, Study of Process Variables, and Relative Gasification Characteristics of Coals of Different Rank.

RI 5560 Survey of Face Ventilation Practices in Coal Mines.

RI 5564 Beneficiating a Complex Sulfide-Oxide Lead-Zinc Ore from Missouri.

RI 5566 Experimental Treatment of Base-Metal Ores From California and Nevada.

RI 5570 Liquid-Liquid Extraction of Rare-Earth Elements.

RI 5561 Geologic Factors Related to Block Caving at San Manuel Copper Mine, Pinal County, Ariz.

RI 5569 Washability Characteristics of Mammoth and Holmes Vein Anthracites.

RI 5572 Preparation Characteristics of Coal from Monongalia County, W. Va.

RI 5573 Operation of Pressure-Gasification Pilot Plant Utilizing Pulverized Coal and Oxygen. A Progress Report.

RI 5575 Experimental Smelting of Aluminum Silicates to Produce Aluminum-Silicon Alloys.

RI 5576 Utilization Studies on Chromite from Seiad Creek, Calif.

RI 5577 Examination of Ilmenite-Bearing Sands in Otter Creek Valley, Kiowa and Tillman Counties, Okla.

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Bulletin 1071-D Geology of the Huerfano and Custer Counties, Colo., $1.25.

Bulletin 1072-M Geology and fuel resources of the Mesa Verde area, Montezuma and La Plata counties, Colo., $1.25.

Bulletin 1074-F Geology and uranium occurrences in the Miller Hill area, Carbon County, Wyo., $1.

Bulletin 1087-D Geology and uranium deposits of Monument Valley, San Juan County, Utah, $1.

Bulletin 1095 Bibliography of North American geology. $1.75.

Bulletin 1105 Selected annotated bibliography of gypsum and anhydrite in the U. S. and Puerto Rico, 50¢.

Bulletin 1106-D Geophysical abstracts 170, October-December 1959, $1.75.

Bulletin 1109 Geologic appraisal of dimension stone deposits, $1.

Bulletin 1112-A Selenium in some epithermal deposits of antimony, mercury, and silver and gold, 15¢.

Water-Supply Paper 1457 Ground-water conditions in the Avenal-McKittrick area, Kings and Kern counties, Calif., $2.25.

Water-Supply Paper 1458 Geology and ground-water resources of the Rawlins area, Carbon County, Wyo., $1.

Water-Supply Paper 1539 Surface water supply of the U. S., 1958 part 6-A. Missouri River basin above Sioux City, Iowa, $1.50.

Water-Supply Paper 1543 Surface water supply of the U. S., 1958, part 13, Snake River basin, $1.

Water-Supply Paper 1567 Surface water supply of the United States, 1958, part 13, Snake River basin, $1.

Water-Supply Paper 1568 Surface water supply of the United States, 1958, part 14, Pacific slope basins in Oregon and lower Columbia River basin, $1.

Circular 414-A Conservation and water management: Conservation and protection, gratis.

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Circular 414-D Conservation and water management: Ecological systems and the water resource, gratis.

Circular 421 Sediment discharge and stream power—A preliminary announcement, gratis.

ABSTRACTS

In This Issue: *The following abstracts of papers in this issue are reproduced for the convenience of members who wish to maintain a reference card file and for the use of librarians and abstracting services. At the end of each abstract is given the proper permanent reference to the paper for bibliography purposes.*

Denison Mine Operation at Elliot Lake by *J. Kostuik* and *M. J. de Bastiani*—The method of mining the uranium orebody at Denison mine in the Elliot Lake district of Ontario is discussed. Author gives details of the development of haulageways and rooms, as well as methods of ore haulage. The milling and beneficiation stages are noted briefly. **Ref.** (MINING ENGINEERING, **December 1960) p. 1230.**

Shaft Sinking in Heavy Ground by *Richard P. Gerwels*—The modification of a three-compartment rectangular shaft to a four-compartment elliptical shaft solved a serious problem of rock pressure which threatened to terminate a shaft-sinking project in Cuba. The case history details the cause and effect of the heavy ground and discusses the benefits derived from the change in the shape of the shaft. **Ref.** (MINING ENGINEERING, **December 1960) p. 1257.**

Portrait of Chuquicamata as a Young Mine by *T. D. Sawyer*—The author recalls the problems confronting the operators in the development of the Chiquicamata mine during the early years, from 1914 to 1919. Details of the mining, milling, and beneficiation of the ore, as carried on in those days, are provided. **Ref.** (MINING ENGINEERING, **December 1960) p. 1260.**

LPF at Miami by *J. J. Bean*—A review of the leach-precipitation-flotation process that was employed at Miami, Ariz., during the years 1957-1958. The flowsheet of the operation, designed to beneficiate mixed sulfide-oxide copper ores, is described in detail. **Ref.** (MINING ENGINEERING, **December 1960) p. 1265.**

Portable Crusher for Open Pit and Quarry Operations by *J. B. Kochanowsky*—There are open pit mining and quarry operations where a mobile crusher arrangement could be more profitable than the facilities now used. The author cites examples of where portable crushers have proven their value and describes how crushers might be of value in other operations. **Ref.** (MINING ENGINEERING, **December 1960) p. 1271.**

SME Meeting Papers: *The following abstracts of papers presented at SME meetings are given for your information. Preprints of these papers are not available.*

Stripping Machinery Mass, Overburden Volumes Relationships by *Henry Rumfelt*—Stripping machines are given values according to their ability to do work. The unit of values, called MUF, is determined for each dragline and shovel by the product of the dipper size and an arbitrarily selected operating reach. Relationships of these values are determined for each machine to the gross weight of each. Next, the required MUF numbers are determined for both a

(*Continued on page 1212*)

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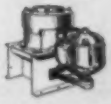
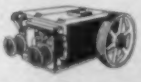
4"x 6" Massco Laboratory Jaw Crusher

Welded steel frame; manganese steel jaw and cheek plates; bronze bushed bearings; smooth jaws give better product and easier cleaning. Adjust for plate wear and product size by convenient hand wheel adjustment.



6" and 10" Massco Gy-Roll Reduction Crusher

Reduces ½" feed to as fine as 10 mesh in single pass. High capacity, low power consumption.



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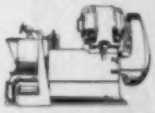
Sizes (Diameter x width): 8"x 4", 10"x 6", 10"x 8", 12"x 10" and 12" x 12". Adjustable roll space setting up to ¾". Double V-belt drive. Heavy, cast Meehanite frame absorbs vibration, results in long life.



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Disc type grinder with a planetary movement. No gears. Will grind ¼" to 150 mesh in one pass.

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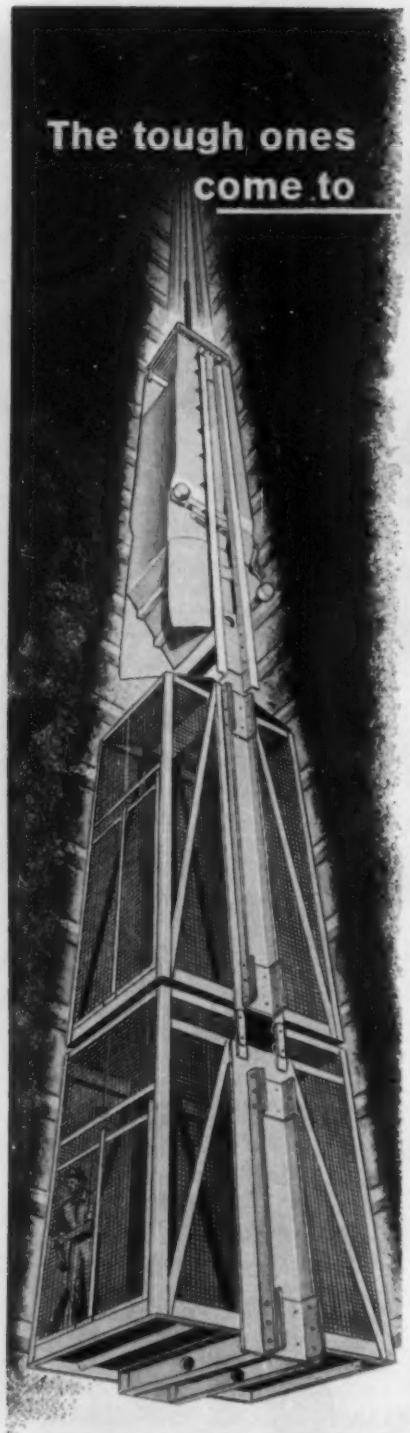

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At Wallace, Idaho, a small shaft is producing up to 12,000 tons of silver-copper ore per month using Card automatic bottom dump skip-cage combination. Skips are rated at 125 cu. ft., handling 16,000 pounds per trip. The ore pocket is kept filled with Card cars, both rocker-dump and Granby types. Surface haulage utilizes larger Card cars, 60 cu. ft. Granby type.

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ABSTRACTS

(*Continued from page 1211*)

shovel-type and a dragline-type operation through a range of overburden depths through the derivations of formulas. An illustrative example shows how the digital computer can be employed to approximate the machine gross weight, the dipper (or bucket) size, and the operating reach for any depth overburden within the range under consideration. *Joint Meeting SME Coal Division-AIME St. Louis Section, St. Louis, September 1960.* 60F300.

Oklahoma-Arkansas Coals by *B. L. Curry*—The original reserves of coal in Oklahoma and Arkansas are estimated at 5773 million short tons, and the reserves remaining in the ground as of Jan. 1, 1953, are estimated at 5250 million short tons. All available information about the location, thickness, and extent of the coal beds in the Oklahoma-Arkansas area was used in this estimate, which includes only coal in beds 14 in. or more in thickness and within 3000 ft of surface. The major part of the estimated remaining reserves of coal in Oklahoma is of high-volatile bituminous rank, 13 pct of medium-volatile bituminous rank, and 22 pct of low-volatile bituminous rank. The greater part of the remaining coal reserves in Arkansas is of low-volatile bituminous rank. *Joint Meeting SME Coal Division-AIME St. Louis Section, St. Louis, September 1960.* 60F301.

Shaft Sinking and Lining in Illinois Coal Field by *J. W. MacDonald*—Review of equipment, performance, and shaft design plans including headframe for sinking and forms for lining. Comparative data for shafts 11x20 ft and 19 ft 9 in. x 30 ft with 756-ft and 666-ft respective depths. Outline of advantage from curtain wall installation with *slip forms* which warrant consideration for normal lining. Preliminary review of *chemical grouting* to stop water inflow leakage with Halliburton equipment and service. *Joint Meeting SME Coal Division-AIME St. Louis Section, St. Louis, September 1960.* 60F302.

The Winning of Fluorspar — Our Area's Most Strategic Mineral by *Gill Montgomery* and *Durward C. Spees*—Most of the nation's fluorspar has been produced from the small area in Southern Illinois and Western Kentucky bisected by the Ohio River. It is presently the principal source, particularly of acid-grade fluorspar, inasmuch as the large known western deposits cannot compete with Mexican and European imports because of adverse freight and production costs.

Since much of the Illinois reserve occurs as flatbedded deposits, mechanization and use of diesel haulage equipment permit economical mining practices.

Improved flotation milling methods have made it possible to process hitherto noncommercial low-grade or tightly locked ores. *Joint Meeting SME Coal Division-AIME St. Louis Section, St. Louis, September 1960.*

The Adaptability of Illinois Coal for Use in the Iron and Steel Industry by *Hubert E. Risser*—The last 15 years have seen a marked growth in the use of Illinois coal for production of metallurgical coke, primarily for three reasons: 1) Research and experimentation have shown that satisfactory blast furnace coke can be produced by proper blending of Illinois coal with more strongly coking coals. 2) Improved preparation has enabled Illinois coal producers to reduce undesirable impurities and improve the uniformity of their product. 3) The combination of easily mined coal seams and proximity to market has given Illinois coal an economic advantage in competing in the midwestern market.

Figures show that the relative economic advantage of Illinois coal with respect to mining and transportation costs and to reserve position has been steadily increasing.

Declining availability and increasing costs of coking coals from traditional sources will give further impetus to this trend. Recent technological trends in the steel industry promise to strengthen the coal industry of Illinois even more. *Joint Meeting SME Coal Division-AIME St. Louis Section, St. Louis, September 1960.*

Meramec Mining Co.'s Pea Ridge Project by *E. L. Bilheimer*—This presentation will consist of 35 to 40 colored slides illustrating the progress of this enterprise from its beginning to the present time. Each slide will be identified and commented upon. *Joint Meeting SME Coal Division-AIME St. Louis Section, St. Louis, September 1960.*

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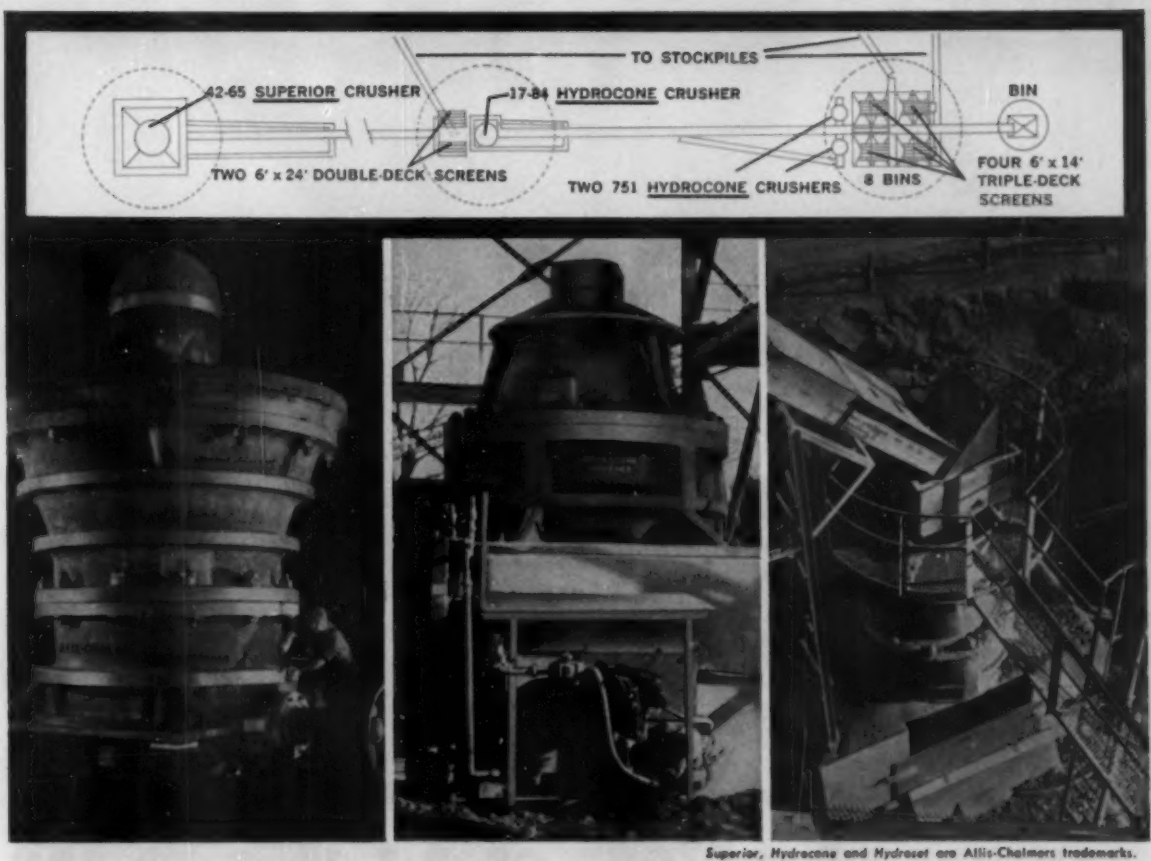

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Rugged Hydroset control sets a fast pace for crushers:

900,000 tons in 4½ months!

Crushing trap-rock is a tough assignment. A tight time schedule makes it even tougher for Chantilly Crushed Stone Company. They were awarded the contract for all of the crushed stone — base course and concrete specification stone — for the new $75,000,000 John Foster Dulles Airport just outside Washington, D. C.

To meet production requirements, they had to have crushers that were rugged and dependable. Crushers that would provide rapid compensation for the wear that always accompanies the crushing of trap-rock. Crushers that would *not* require extensive downtime to unload in the event of power failure.

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It was *Hydroset* control that made compensations for wear in minutes, not hours... made the quick changes in product size from base course to concrete specs.

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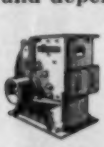
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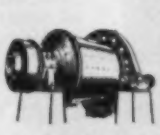
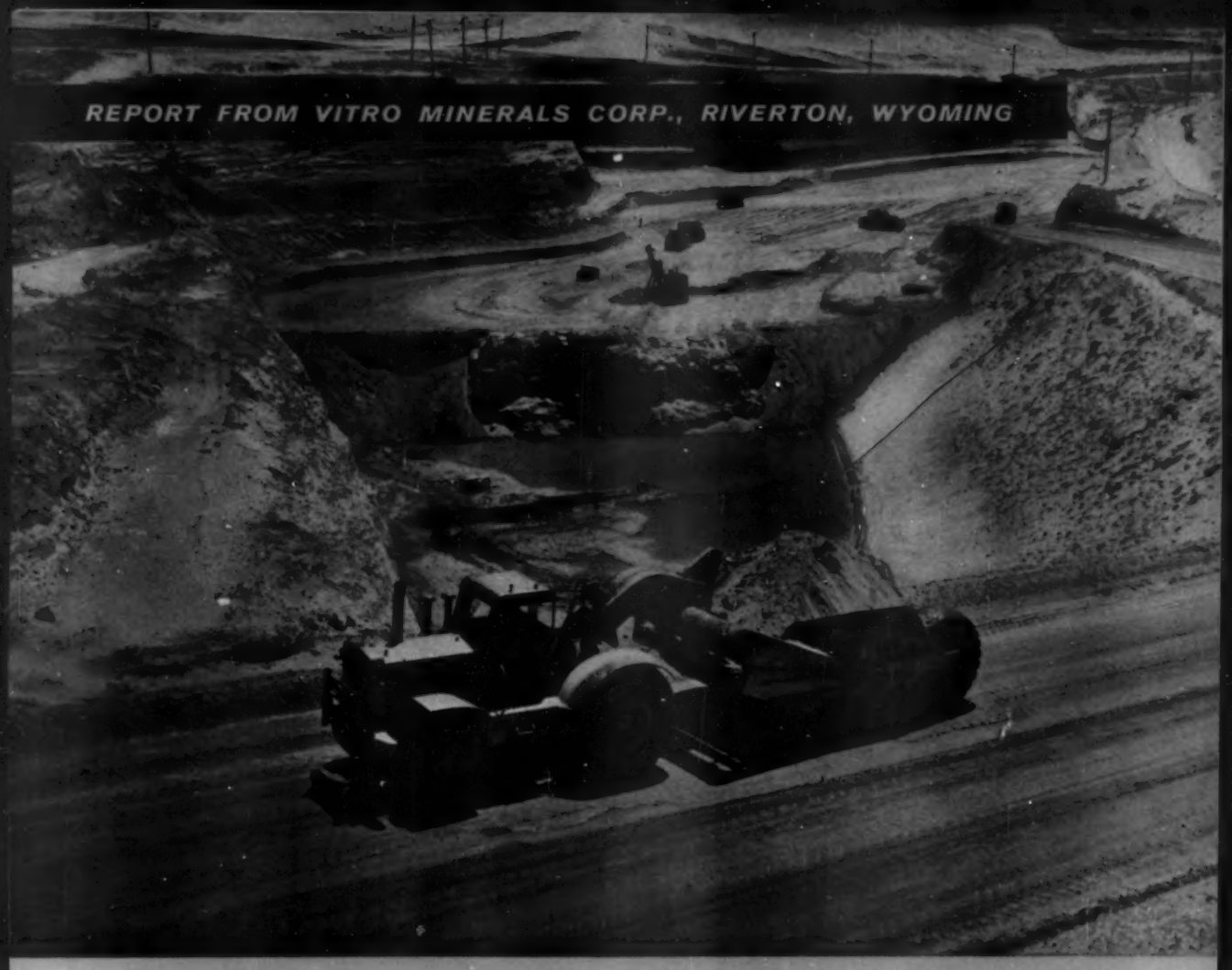
Vibrating Screen

Jaw Crusher


Grinding Mill

Kiln



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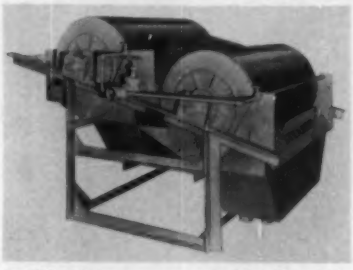
Permanent Ceramic Magnet Separator

Stearns Magnetic Products has reported the first permanent ceramic magnet wet drum separator designed especially for cobbing applications in the concentration of magnetite and reduced hematite ores. The



double-drum concurrent style units feature non-magnetic, corrosion-proof stainless steel feed boxes and collection tanks as well as a special wear-resistant cylinder material. The separators have 36-in. diam cylinders with 24-in., 36-in., 48-in., 60-in., or 72-in. widths. **Circle No. 1.**

Explosives for Seismic Exploration

American Cyanamid Co. has developed two new explosives to assist seismic explorations. "Cyamon *S*" nitro-carbo-nitrate blasting agent, and "Cyamon *S*" primer are available in 1-lb capacity threaded metal containers which can be easily coupled for column loads. The primer container has a recessed well capable of accommodating any seismic cap now available. **Circle No. 2.**

Shuttle Car

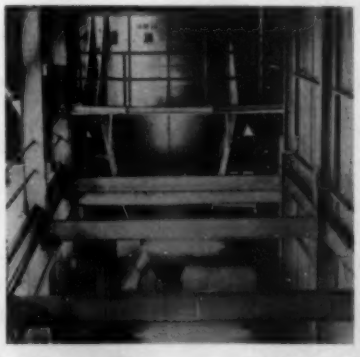
Goodman Mfg. Co. has developed its AC shuttle car for use in metallic, non-metallic, and coal mining. With a basic height of 44 in. or 49 in. and a width of 96 in. or 106 in., the car can transport 13 tons of rock or 10 tons of coal with an increase possible through use of added sideboards. The unit has an 11½-in. ground clearance, is powered by an 80-hp traction motor permitting two-speed operation (2½ mph or 5 mph), and has a 26-hp motor to power a mechanical conveyor drive and hydraulic system. **Circle No. 3.**

Yieldable Arches

Yieldable steel arches of special quality mine steel, designed to resist extensive ground pressures in mines where openings are maintained within fixed limits, are now being marketed by *Commercial Shearing and Stamping Co.* called Commercial T-H yieldable arches, they are fabricated to specific patterns and are available in seven sizes from 3-in. to 7-in. widths. A friction contact area confined to specially designed flanges and side webs provides efficient, trouble-free yielding. As a result, the company reports, no friction exists between horizontal webs, thereby eliminating buckling under excessive pressure. **Circle No. 4.**

Centrifugal Separator

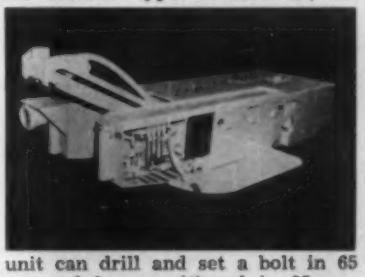
The Superfine Whirlwind Centrifugal Selector, previously only custom-engineered, is now commercially available from *Sturtevant Mill Co.*



Developed for recovering micron-sized fines difficult or impossible to classify with standard air separators, the new units are now manufactured with 3-ft and 6-ft diam. The selector may be used alone, in closed circuit with grinding mills, or with existing separators. The unit is reported to provide a greater centrifugal effect for initial separation than is normally utilized. **Circle No. 5.**

Roof Bolting Machine

One-man operation and high maneuverability feature the LRB Roof Bolting Machine developed by the *Long-Airdox Co.* for use in coal mining. The unit has a 27-in. height, 40-in. width, and 108-in. length. Designed with variable drilling speed for different types of material, the



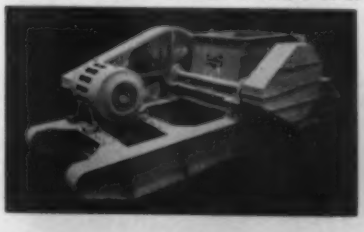
unit can drill and set a bolt in 65 sec and be repositioned in 25 sec. Capable of operating at the working face, the machine can also be furnished with a hydraulic face drill to permit simultaneous roof bolting and face drilling. **Circle No. 6.**

Heavy Duty Conveyor Belting

The Goodyear Tire & Rubber Co. has introduced a woven carcass rubber conveyor belt which is reported to withstand abuse far beyond conventional ply-type belting. Designed for long life in hard-rock mining operations, the belt features a carcass of interlocked nylon-reinforced cotton yarn. Described as having ten times the rip resistance of conventional cotton duck belts and three times that of cotton-nylon ply belts of comparable strength, the belt offers unusual resistance to cover separation because of built-in protection against internal ruptures resulting from trapped lumps and excessive pulley build-up. **Circle No. 7.**

Skid-Base Crusher

McLanahan and Stone Corp. has put its Black Diamond single-roll crusher on heavy duty skids, permitting the unit to be easily moved in following underground mining operations. The unit has a 22 x 7-ft skid base, a 100-hp motor, and a 36 x 48-in. crusher. The design includes split frames on the crusher and skid to allow entry through very narrow vertical shafts. **Circle No. 8.**



NEW PEAK in PAYLOAD!!

Introduced at the Mining Congress Convention this October, KW-DART'S 95EDT is the company's latest contribution to the mining industry. Its payload is 95 tons.

This tractor-trailer, the 70EDT, is a 70 ton hauler that has established enviable performance records in a number of mines in recent years.

The 50EDT carries 50 tons as a tractor-trailer. It utilizes KW-DART'S popular 25SL as a tractor. Its enthusiastic approval by mining operators fostered development of the larger units.

KW-DART CLIMAXES 57 YEARS OF ENGINEERING WITH THREE HIGH CAPACITY TRACTOR-TRAILERS

A new concept in heavy duty haulage was born with KW-DART'S tractor-trailer design. It enables moving greater tonnages with negligible sacrifice of maneuverability and without added horsepower.

These tractor-trailer combinations utilize KW-DART'S proved components, *engineered to your job.*

KW-DART TRUCK CO.®

1301 North Manchester Trafficway • Kansas City 41, Missouri, U.S.A.

(21) VIBRATING SCREEN AND HEATER: A four-page leaflet issued by *The Deister Concentrator Co. Inc.* describes the Leahy Model E vibrating screen with "FlexElex" heater and lists the features which make possible fast and efficient sizing of damp and sticky materials that blind conventional unheated screens. The screen offers differential motion which keeps meshes clear of intermediate size wedging particles, and the heater keeps the screen wires warm and dry for uninterrupted high production.

(22) DUAL-HITCH BUCKETS: *Page Engineering Co.* has released brochure No. DH-360 describing its new dual-hitch automatic dragline bucket. The two-color, six-page booklet shows the bucket in action and illustrates its many outstanding features including instant uniform digging action, greater digging control, and increased yardage.

(23) ORE BALL MILL: A single-page, illustrated process application sheet (12-1) has been issued by *Bailey Meter Co.*, which describes the operation of a Bailey ore ball mill and classifier control. A basic diagram of a control system is included to illustrate how application of the system increases grinding efficiency, improves metal recovery, decreases variations in flow to flotation, controls grade of concentrate and reduces labor. System components are also listed and described.

(24) DETONATING FUSE: A 72-page pocket-size catalog and manual describing the Primacord Detonating Fuse has been issued by *The Ensign-Bickford Co.* The catalog section covers the six standard brands of detonating fuse for commercial blasting manufactured by the company, and the manual illustrates and describes approved operations in priming, loading, and hooking up Primacord for instantaneous and delayed firing. The text covers use of detonating fuse in mining, stripping, quarrying, and construction work.

FREE LITERATURE

(25) SANDHOG EQUIPMENT: Bulletin No. 23, a four-page illustrated leaflet describing installations of man locks, muck locks, tunnel shields, air locks and lock doors, grouters and pea shooter cars, as well as many types of tunnel cars and allied equipment, has been issued by *Mayo Tunnel & Mine Equipment.* The Scott tunnel excavator, which the company manufactures, is also shown.

(26) REVISED TESTING SIEVE SPECIFICATIONS: A bulletin covering 1960 revised specifications for testing sieves embodied in the new ASTM specification, as well as specifications being proposed as international standards, has been issued by *The W. S. Tyler Co.* The eight-page illustrated booklet, No. 606, also describes testing sieves made to the new specifications plus other Tyler laboratory equipment.

(27) CUTTER BITS: A bulletin describing its complete line of cutter bits has been issued by *Austin Powder Co.* It lists applications for 9 models in 2 series and discusses advantages of each.

(28) CRADLE IDLER AND BELT CONVEYOR: An impressive presentation from *McNally Pittsburgh Mfg. Corp.* gives complete information on its cradle idler and belt conveyor. This 18-page, profusely illustrated brochure (No. 660) contains descriptions, photographs, dimensional drawings, and capacity tables of the cradle idler, idler *H*-frames, and belt conveyor. Information is given on the use of these belt conveyors for underground material handling. Also included is a description of pre-engineered conveyor sections.

(29) ROCK CRUSHER: An attractive four-page, two-color bulletin describing the new Pulvo-Matic, a rock crusher with only one moving part, has been issued by *The Frog, Switch & Mfg. Co.* The booklet notes the advantages of this crusher operating on the principle of applying direct impact action plus centrifugal force. The amount of the impact depends entirely on the rotating speed of the cage; thus the higher the cage rpm, the finer the aggregate. These factors are easily and accurately controlled in this unit. Illustrations, diagrams, and specifications for three crusher sizes are included.

(30) FLOTATION MACHINE: An eight-page booklet (bulletin F5-B23) recently issued by *WEMCO*, a division of *Western Machinery Co.*, describes and illustrates the principle of the flotation process for selectively separating finely divided mineral particles. It also deals with the design, construction, and operating characteristics of WEMCO-Fagergren flotation cells.

(31) CORE DRILL APPARATUS: The Acker Presidenté, a new core drill rig designed for rugged field service, very deep core drilling and versatile operation is described in a six-page illustrated folder recently published by *Soiltest Inc.* The folder (bulletin No. 31) fully describes the rig's many special features including the hydraulic drill head, octagonal spindle, automatic chuck, and hoists and sealed hydraulic circuit. Related accessories such as line masts, water pumps, diamond bits, and core barrels are also detailed.

(32) CONTROL CENTER: *General Electric* has issued four-page bulletin GED-4152 detailing the latest significant achievements in motor control centers. Some of the 40 new features incorporated in the control centers are pictured, including the positive unit guidance system, isolated wire trough, and unique sliding covers.

mail this post card for more information

12

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Students should write direct to manufacturer.

(33) GAS CHROMATOGRAPHY: *Armour Industrial Chemical Co.* has issued a catalog of 30 neo-fats showing specifications and composition under gas chromatography. The company is reported to be the first producer of fatty acids to adopt the use of gas chromatography analysis to determine product compositions as an aid in closer control of strict specification processing.

(34) ROTATING DISCS: Four-page bulletin No. 247, covering the company's standard line of rotating discs for pelletizing or mixing such materials as ore fines, phosphates, ceramic clays, fly ash and oxides, has been published by *Dravo Corp.* Of interest to the mining, aggregate and coal industries, the leaflet cites design features and advantages of the discs which range in diam from 39 in. to 16 ft. 5 in. Stressed are the classifying action of the disc in producing pellets of uniform size; the high output of the disc through continuous operation; the easy adjustability of plows, pan angle, and rotating speed; the high quality of pellets produced; and the low overall cost per ton of output.

(35) BELT SLINGS: *The Wire Rope Div. of Jones & Laughlin Steel Corp.* has issued a folder describing its new line of "Safety-Weave" synthetic web belt slings. The brochure contains useful information about both Nylon and Dacron slings including data showing their resistance to all common agents. Charts are supplied which list dimensions and capacities of slings in vertical, choker, and basket applications.

(36) LIQUID FEEDER: Bulletin No. 606 describing a new liquid feeder has been released by *The Clarkson Co.* The model is designed for controlled feeding of sulfuric acid and other corrosive liquids. Adjustable from a few drops per minute to 764 gal per day, the feeder is adaptable to either remote, manual or automatic control.

(37) BELTING: *The Boston Woven Hose & Rubber Div. of American Biltrite Rubber Co.* recently issued a 36-page catalog giving complete specifications and information on the company's full line of conveyor, elevator, and transmission belting. In addition to the detailed data, cross-section illustrations show the construction of each belt. One section of the catalog is devoted to helpful tables dealing with belt weights, belt gauges, fabrics, and belt recommendations.

(38) FITTINGS AND FLANGES: *The Tubular Products Div. of Babcock & Wilcox Co.* has published an eight-page booklet, FB-502A, on seamless welding fittings and flanges available in carbon, alloy, and stainless steels. The brochure includes charts of standard sizes and schedules according to ASA B36.10 and ASA B36.19, and also contains a comprehensive breakdown of dimensional tolerances, illustrations of the most commonly produced fittings and flanges, and a chart of the sizes and types available.

(39) CENTRIFUGAL PUMPS: Bulletin 105-V, a flyer from *Aurora Pump Div. of The New York Air Brake Co.*, illustrates and describes the line of verticle single-stage split case centrifugal pumps recently introduced by the company. These pumps retain the characteristics and performance features of the horizontal split case line and are reported to be ideal for applications where extreme compactness is important.

(40) AIR FILTERS: An eight-page catalog recently issued by *King Engineering Corp.* describes its line of compressed air filters designed to remove practically 100 pct of the entrained dirt, oil, and water from the air and to operate normally for months without maintenance. The catalog includes photographs and diagrams of individual models, specification charts, and maximum permissible flow rate graphs.

(41) SEMI-AUTOMATED WEIGHING SYSTEM: A leaflet issued by *The Exact Weight Scale Co.* tells how, by combining scales with calculators and other equipment through use of a binary code, a new low cost semi-automated weighing system for process, quality, and cost control can be achieved. Applications of the basic weight classification system may be limited to simple sampling techniques or extended to provide closed loop feedback controls for sorting and separating products into weight groups while simultaneously recording and counting.

(42) DRILLING EQUIPMENT: To introduce its new series of drilling equipment for practically every phase of mining, *Chicago Pneumatic Tool Co.* has issued a 16-page, illustrated booklet, SP-3286. Equipment covered includes crawler-mounted rotary drill rigs, in-hole percussion drills, air-blast bits, and easy handling demolition tools. Specification charts are included.

(43) EXCAVATOR: Bulletin No. L-1083, "Shaft Mucking with the 630," issued by *The Eimco Corp.*, is filled with case histories, actual operational results, and economies reported by some of the world's major companies and contractors using this excavator. The eight-page bulletin includes pictures of the 630 excavator in operation in the U.S. and in South Africa. Also included are the best proven methods for mucking with the 630, lifting and lowering it into shafts, and sinking tubs or buckets.

(44) REVOLVER FEEDERS: Revolver feeders (blow-through type) designed for feeding dry, pulverized, and granular materials into high-pressure pneumatic conveying systems with small diam lines are described and illustrated in two-page bulletin F-9, recently published by *Fuller Co.* Dimensional drawings and specifications for all sizes of revolver feeders are included. Eight key dimensions are listed for each model plus drive motor specifications, line size, and weight.

(45) LABORATORY PRECISION BALANCE: *The Exact Weight Scale Co.* recently issued a bulletin describing and illustrating its Series *K* general purpose high speed precision balances designed for small capacity industrial weighing operations of all types. Bulletin 3414 includes complete specifications and operating instructions.

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MARION

ANNOUNCING LE ROI'S

A new line of powerful . . . highly portable . .

These rigs come on tires or tracks!

THE LRD-2

Here's a highly portable blasthole drill for making hole up to 4½ inches as deep as 30 feet . . . equipped for either positive-drive rotary drilling or powerful down-the-hole percussive drilling.

What's more, the LRD-2 is completely self-contained . . . and economically priced, too!

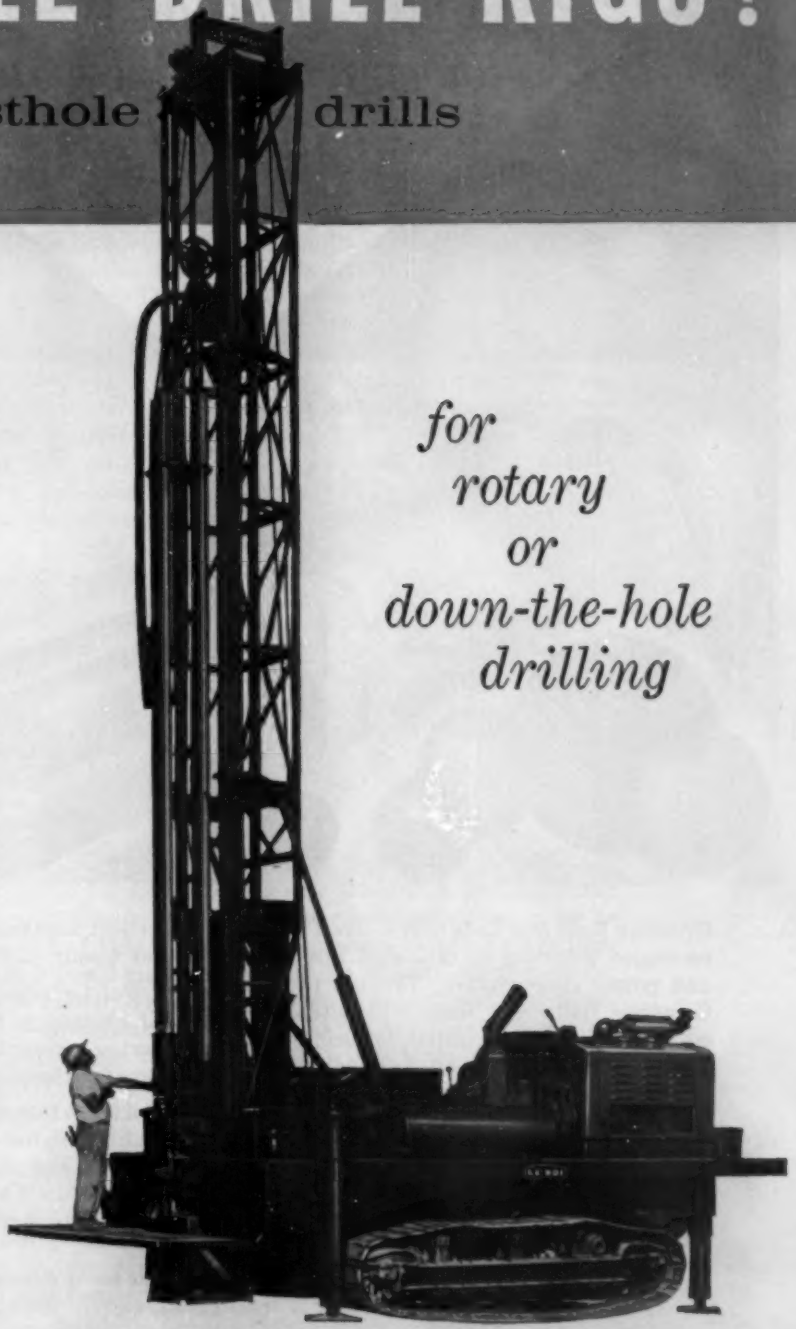
The entire unit is easily handled by one man. Controls are conveniently grouped at an operator's station located alongside the drilling area. The unit can be moved, leveling jacks hydraulically set, boom hydraulically raised, drill pipe and bits connected, and hole started — all with a few non-fatiguing motions.

Powerful direct mechanical drive keeps the rotary table turning — won't bog down or lose torque under rough going like air or hydraulic driven units — eats through tough rock formations under 10,000 lbs. pulldown pressure at speeds from 40 to 250 rpm. If necessary, a hard-hitting down-the-hole drill can quickly be substituted for the rotary bit to drill extremely hard rock formations. A Le Roi 25 hp two-stage air compressor provides ample air for powering the down-the-hole drill and cleaning out hole . . . or is available in single-stage where only rotary drilling is necessary.

The self-propelled LRD-2 is available either on crawler or tire mounting and with either gasoline or diesel power unit. A whole list of extra equipment is available to ease or speed drilling, including lights for night-time operation, a mounted bit grinder, air hoist, breakout tongs, water injection system, etc. . . . all detailed in Specification Sheet AT-146. Write for your copy.

DEEPHOLE DRILL RIGS!

rotary blasthole drills



for rotary or down-the-hole drilling

THE LRD-3

Here's the *big* rig . . . completely self-contained for putting down hole as large as 7⅞ in. to 100 ft. depth!

The LRD-3 is available with either crawler or truck mounting. An enclosed cab can be furnished to provide all-weather protection for the operator while drilling. All controls are conveniently grouped for easy operation and good visibility.

The traveling head design of the LRD-3 provides positive mechanical power without excessive torque loss under heavy pulldown, and permits easy control in making up and breaking down drill-rod. Every function of the unit is designed to speed productive drilling and keep the operator making hole. Leveling, raising the mast, and even the automatic drill pipe magazine are hydraulically controlled for speedy operation. A powerful dust collector traps cuttings and blows them well away from the unit.

An extra-sturdy 4-speed chain-hydraulic pulldown puts up to 30,000 lbs. of pressure on the bit of the LRD-3. A rugged dual-range transmission provides rotary speeds from 9 to 168 rpm in a selection of 10 forward and 2 reverse speeds.

Where needed, the rotary bit can be quickly changed for a powerful down-the-hole drill. A Le Roi 100 hp dual-manifold air compressor provides plenty of 100 psi air for punching through tough rock with the down-the-hole drill, or it can be set to deliver 625 cfm of 40 psi air for fast, efficient removal of cuttings in rotary operation.

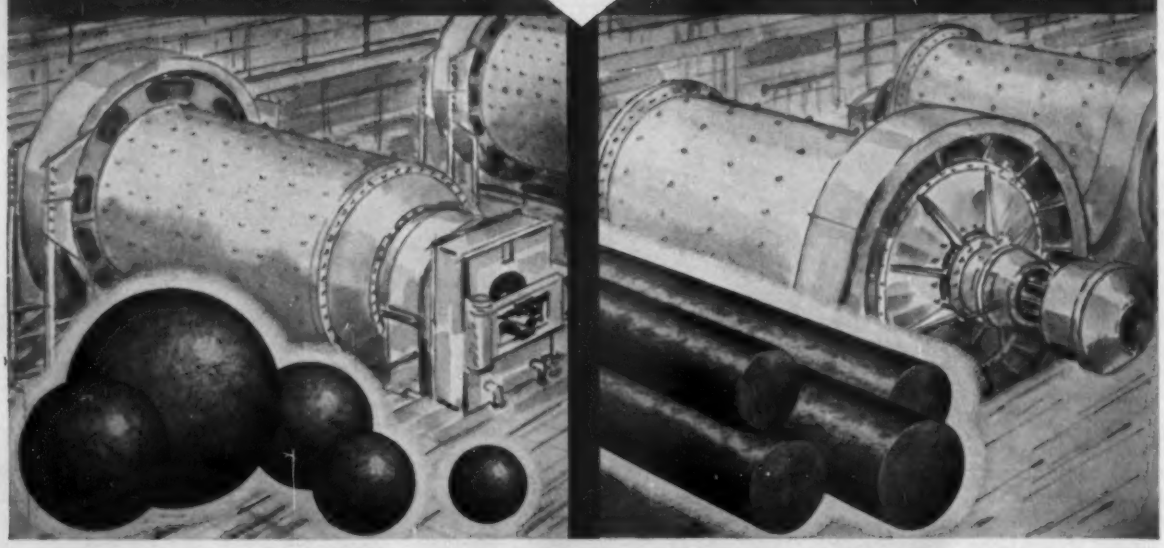
The LRD-3 comes complete with a hydraulically operated magazine with capacity for four 20 ft. drill pipes, and can be equipped with optional convenience equipment similar to the LRD-2. Specification Sheet AT-147 describes the unit in detail, with complete spec information. Send for a copy.

LE ROI

division of Westinghouse Air Brake Co.

Sidney, Ohio

Total grinding costs are lower with CF&I grinding balls and rods



Grinding Balls and Rods have a direct bearing on major grinding costs — mill throughput and power consumption. The use of CF&I Grinding Balls and Rods will actually increase your mill throughput, lowering power consumption per ton of material ground. This is a result of the microstructure of the high quality steel made and used by CF&I.

CF&I Grinding Balls have the balance of hardness and toughness that provides proper wear and impact resistance. In addition, their excellent abrasion resistance permits them to wear evenly and retain their original shape.

CF&I Grinding Rods—through controlled mill chemistry techniques — have excellent wearing properties, resisting bending and premature breakage.

All these factors contribute to more efficient grinding, higher throughput... lower grinding costs. For the complete story on the advantages of CF&I Grinding Balls and Rods, contact your local CF&I sales office.

Other CF&I Steel Products for The Mining Industry

CF&I Industrial Screens • CF&I-Wickwire Rope • CF&I Grader Blades
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In the East: **WICKWIRE SPENCER STEEL DIVISION** — Atlanta • Boston • Buffalo • Chicago • Detroit • New Orleans • New York • Philadelphia

To Develop Big Asbestos Orebody in Newfoundland

The Canadian subsidiary of Johns-Manville Corp. announced plans for joining three other companies in the development of a 22-million-ton asbestos orebody in northern Newfoundland. Canadian Johns-Manville Co. Ltd. will invest about half the $18 million cost involved. The remainder will be shared by investor group Patino of Canada Ltd. and European asbestos consumers Amet Corp. Inc. and Financiere Belge de L'Asbest-Ciment S. A. The decision to develop the property culminates two years of test drilling. Construction will include crushing facilities, fiber mill, storage and service buildings, a road from mine site to waterfront, and a loading dock. Asbestos fiber output is scheduled to begin by mid-1963. The orebody is one of several located in the Baie Verte region of the Burlington Peninsula. Mineral rights are held by Advocate Mines Ltd. through a concession granted by the Newfoundland government in 1955.

$2 Million Columbium Ore Mill Slated

Following the development of an economical milling process for its columbium ore deposits, St. Lawrence Columbium & Metals Corp. has begun building a $2 million concentrator. Output from large open pit deposits on a site at Oka, about 20 miles west of Montreal, will be treated at an initial rate of 500 tpd of ore, beginning in July 1961. With increased demand, concentrator capacity can be stepped up to 4000 tpd.

Texas Gulf Sulphur to Build Potash Plant

Firming up plans announced on this page last month, Texas Gulf Sulphur Co. said it will begin construction immediately on a new $25-million potash mining and processing plant in southeastern Utah. The new plant, scheduled to be in production by about the end of 1962, is designed to produce more than a million tons of muriate potash, and would make Texas Gulf the largest potash producer in the country, the company said. Ore from the deposit at Cane Creek, near Moab, has an average potassium oxide content exceeding 25 pct and is free from clay, simplifying desliming in processing. By the end of 1963, the company stated, commercial output capacity of the new plant may be raised to more than 1.5 million tons annually.

Merger Planned by Reynolds Metals and Tilo Roofing

Substantially completed merger arrangements have been set between Reynolds Metals Co. and Tilo Roofing Co., a producer and distributor of asbestos and asphalt building materials. The agreement, which still requires approval of directors and stockholders of both companies, would reinforce Reynolds activity in the building products field . . . . Reynolds has also been engaged in development, with Reed Roller Bit Co., of aluminum pipe for oil field drilling. Still under test, the pipe will cost more than steel pipe but its light weight will allow rigs to lift longer strings.

Glen Alden Buys Assets of Hudson Coal

Glen Alden Corp. acquired the operating assets of Hudson Coal Co., Scranton, Pa. for an undisclosed price and said the company would become a wholly owned subsidiary.

MINING engineering REPORTER

Inco to Expand Iron Ore Plant at Copper Cliff

International Nickel Co. of Canada Ltd. has announced that it is starting immediately on a program to triple the capacity of its iron ore recovery unit at Copper Cliff, Ont. By using a process successfully tested in the existing plant, the expanded facility will treat 1.29 million tons annually of nickeliferous pyrrhotite high in iron content. H. S. Wingate, chairman, said the process involves "the removal of nickel by atmospheric pressure leaching in high capacity units of novel design. The diversion of this large quantity of pyrrhotite to the expanded iron ore recovery plant will effect a 40 pct decrease in the tonnage of material which would otherwise have to be handled by the nickel section of the Copper Cliff smelter. The change in practice in the nickel smelter," he said, "will result in important smelting economies and provide a basis for further major advance in nickel extractive metallurgy." Output capacity of the iron ore recovery plant will be raised to 900,000 tons of pellet concentrate yearly, from the present 300,000 tons. The expanded plant is scheduled to be in full operation in 1963. Of the total estimated required capital outlay of $50 million, $10 million will be spent in 1961.

Plan Geophysical Survey of Surinam

Surinam, large bauxite producer, will undergo geophysical survey for other mineral resources under a $1.5 million loan granted by the World Bank.

Early End to Great Lakes Ore Shipping Season

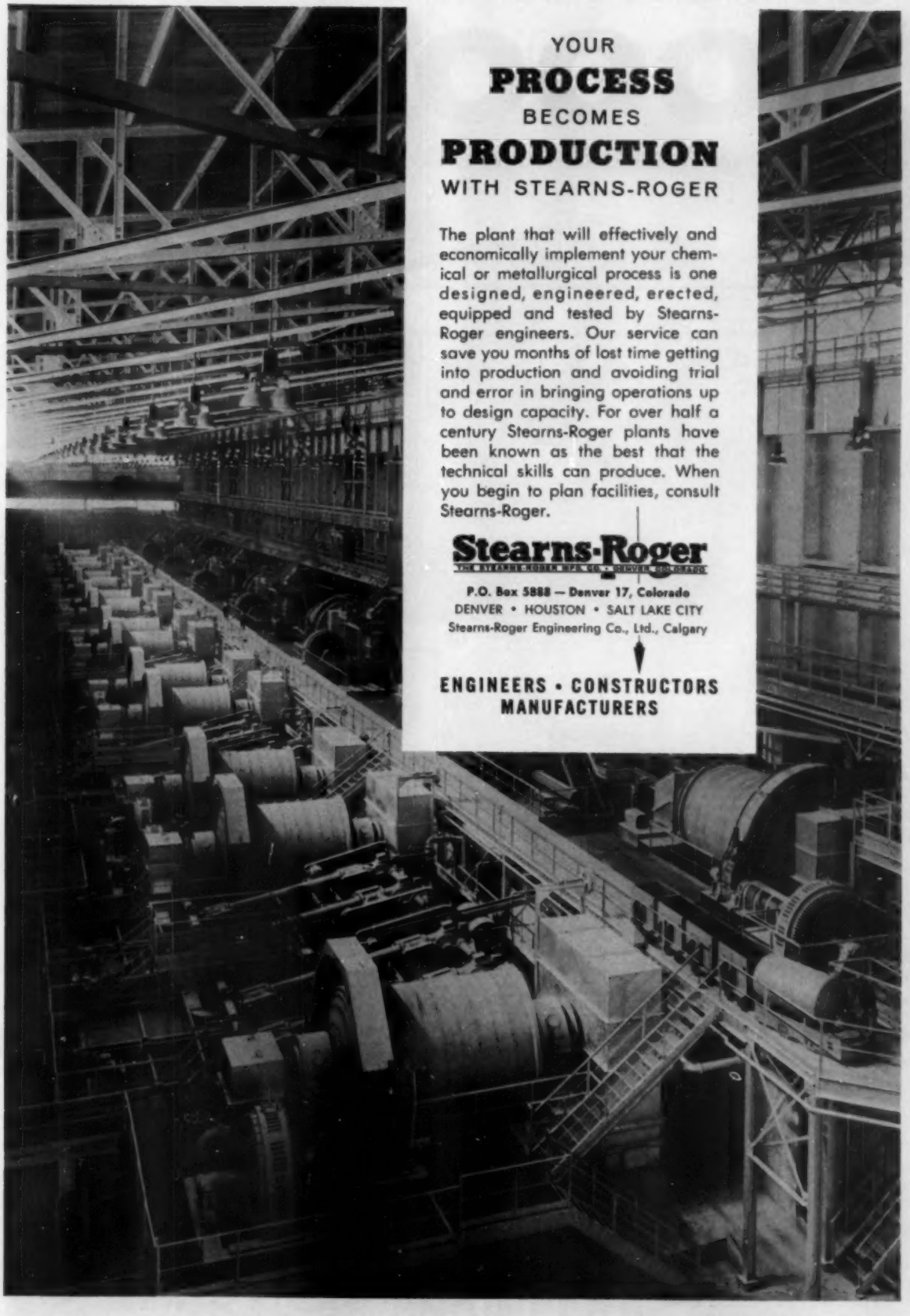
The reduced rate of steel production, combined with higher industry consumption of scrap iron and foreign-produced ore has caused an early waning of iron ore shipments on the Great Lakes. Almost half the working vessels were idled by November 1, and virtually all were expected to be laid up by mid-November. Last year the boats were working almost as late as January to build up stocks depleted by the steel strike. This season ore inventories are running high—October 1 stocks totaled some 74,130,000 tons, compared with about 60,553,000 tons on the same date in 1959.

Power Contract Signed for Montana Project

The big steel plant projected at Anaconda, Mont., by Webb & Knapp Strategic Corp. will be supplied with up to 120,000 kw of electric power by Bonneville Power Administration under terms of a contract signed with the Federal Goverment. Intended to convert the iron content of some 40 million tons of copper slag to steel, the plant will have an annual capacity of 350,000 tons.

National Lead and Bunker Hill Sign Sales Agreement

National Lead Co. and Bunker Hill Co. announced execution of a contract effective January 1, 1961, under which National Lead will purchase Bunker Hill primary lead, special high grade zinc, and cadmium. The agreement covers all production of these metals at Bunker Hill's Kellogg, Idaho, facilities, except for that required by its Fabricating and Chemical Divisions and for calking lead.



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PRODUCTION

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The plant that will effectively and economically implement your chemical or metallurgical process is one designed, engineered, erected, equipped and tested by Stearns-Roger engineers. Our service can save you months of lost time getting into production and avoiding trial and error in bringing operations up to design capacity. For over half a century Stearns-Roger plants have been known as the best that the technical skills can produce. When you begin to plan facilities, consult Stearns-Roger.

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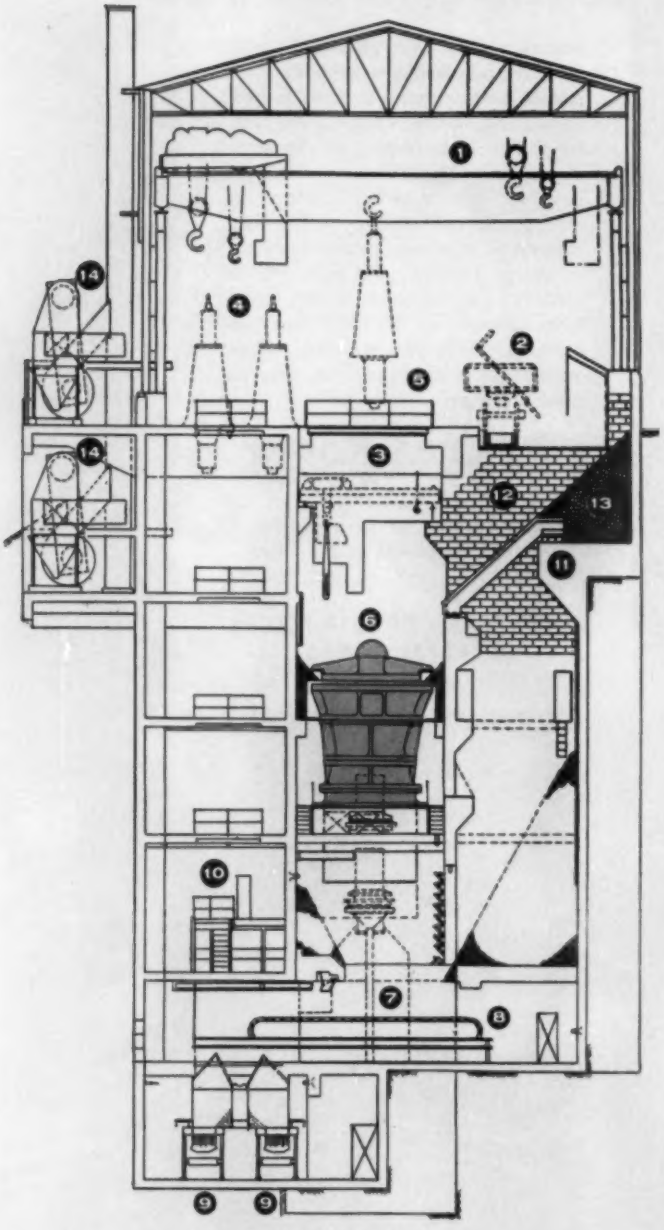

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Chuck Weinke, shop superintendent (left) and R. J. Bakken, welder, with Amsco tooth which has just been repointed. Teeth are retipped with repointer bars welded on with Amsco Nicro Mang and hard faced with Amsco #20 electrodes. This combination produces stronger welds, less cracking and longer wear.

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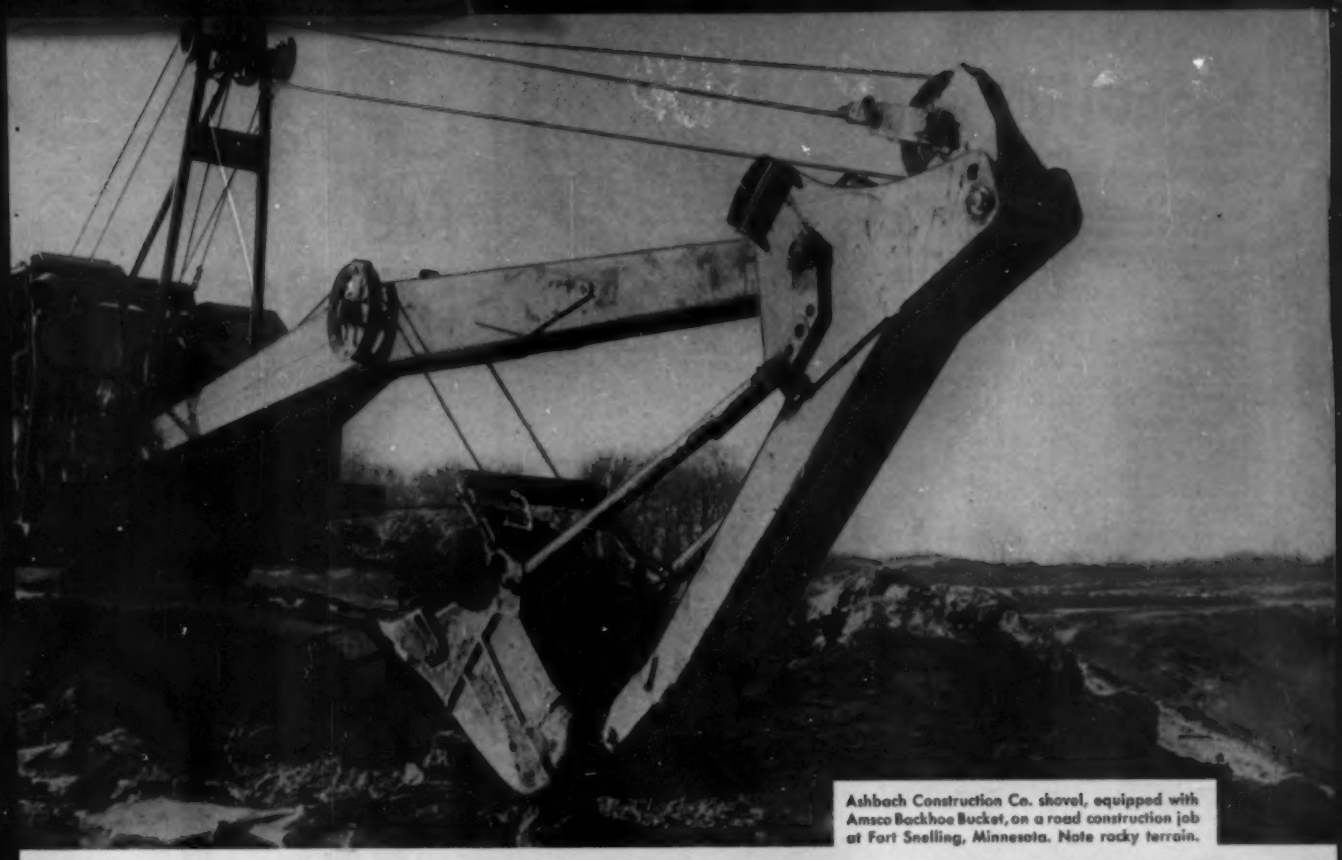


Ashbach Construction Co. shovel, equipped with Amsco Backhoe Bucket, on a road construction job at Fort Snelling, Minnesota. Note rocky terrain.

Russell J. Masters, left, and Elmer Ahlschlager, shovel operator, checking the Amsco teeth on an Amsco Dipper.

SECTION GOALS TO GO

Amounts Still to Be Raised by Various Sections to Attain Goals and Percentage of Section Members That Have So Far Contributed (Nov. 1960):

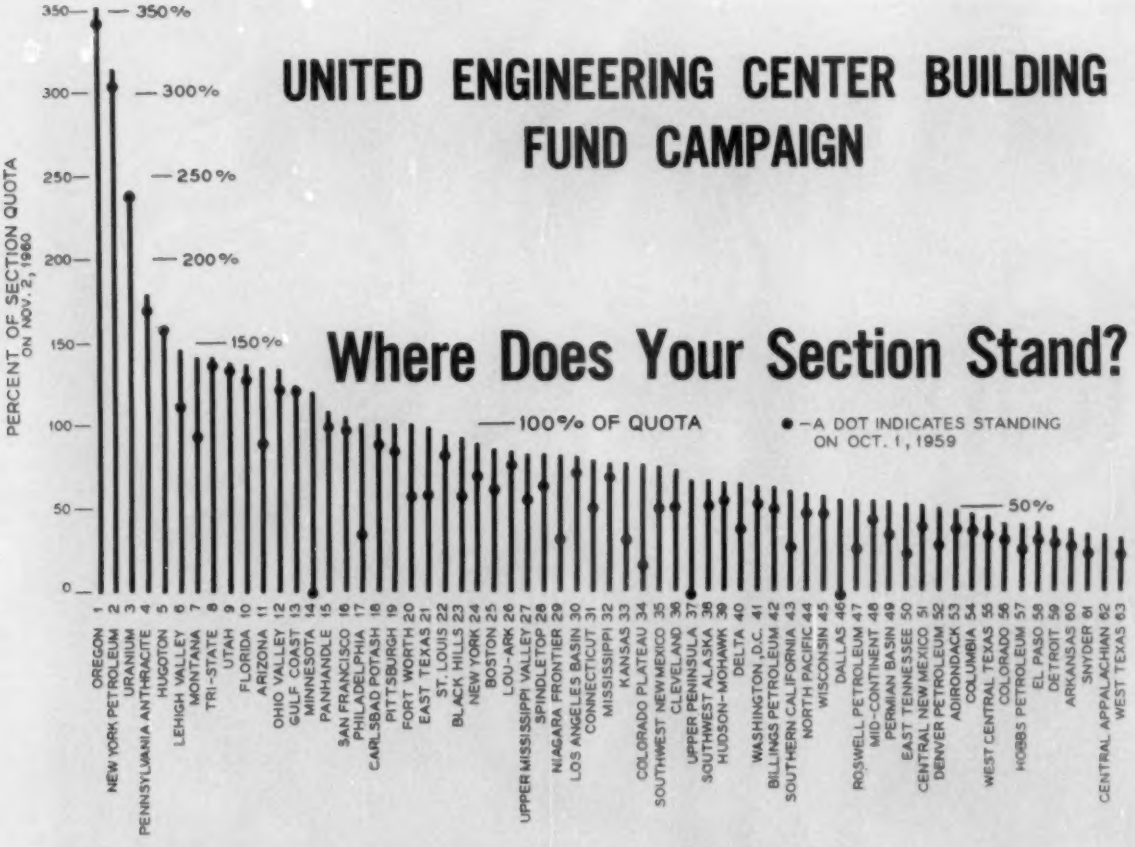
Section	Pct	Amount	Section	Pct	Amount
New York	30	$14,801	Hobbs Petroleum	20	$852
Chicago	10	7,164	East Tennessee	12	819
Oklahoma City	2	5,746	Upper Peninsula	40	714
Southwest Texas	16	5,394	South Plains	38	699
Mid-Continent	34	5,037	Carolinas	4	685
Dallas	33	4,082	Connecticut	24	664
North Texas	1	3,915	Four Corners	24	660
Permian Basin	27	3,556	California Coastal	10	655
Colorado	9	3,050	Colorado Plateau	23	643
Central Appalachian	7	2,770	Billings Petroleum	54	635
Evangeline	15	2,764	Hudson-Mohawk	34	567
Delta	33	2,752	Boston	37	561
Illinois Basin	5	2,700	Wisconsin	19	553
Balcones	7	2,649	Spindletop	41	521
Detroit	9	2,490	Arkansas	13	506
Southern California	13	2,437	Utah Coal	4	480
Southeast	20	2,366	Wyoming Mining & Metals	18	480
Denver Petroleum	31	2,227	Niagara Frontier	20	457
Nevada	4	2,175	Snyder	34	435
Washington, D.C.	26	2,068	Kansas	25	421
San Joaquin Valley	12	2,035	Williston Basin	32	420
Columbia	19	1,968	Lou-Ark	45	415
Wyoming Petroleum	27	1,823	Northern Oklahoma	0	375
Los Angeles Basin	22	1,724	Alaska	5	329
Cleveland	14	1,493	St. Louis	12	286
El Paso	22	1,287	Mississippi	59	266
West Central Texas	40	1,271	Roswell Petroleum	46	250
North Pacific	20	1,215	Southwestern Alaska	42	243
Appalachian Petroleum	31	1,060	Southwestern New Mexico	36	200
Great Bend	15	1,020	Black Hills	35	72
Adirondack	26	879	Upper Mississippi Valley	48	50
Central New Mexico	14	863	East Texas	52	28

Of the Sections that have attained their goals, the following list shows the percentage of members that have contributed:

Section	Percent	Section	Percent
Oregon	58	Ohio Valley	27
New York Petroleum	23	Gulf Coast	59
Uranium	41	Minnesota	—
Pennsylvania Anthracite	42	Panhandle	72
Hugoton	76	San Francisco	16
Lehigh Valley	44	Philadelphia	24
Montana	40	Carlsbad Potash	69
Tri-State	49	Pittsburgh	29
Utah	25	Fort Worth	56
Florida	22		—
Arizona	40	Average 19 Sections	43

Our Faces Are Still Red!

The most ambitious joint activity of the engineering profession is approaching completion. Construction of the new United Engineering Center is proceeding rapidly. The industry drive to raise funds for this Center has produced approximately $5 million dollars. Voluntary contributions from members of all participating engineering societies exceed $3



million. BUT—almost $1 million remains to be pledged. It is hoped that this can be achieved before the end of the year, either in payments or pledges that can be paid over the next three years at the members' convenience.

AIME LAGS

Among the Founder Engineering Societies, *your* professional Society—AIME—lags on a percentage basis, with $84,000 still to be pledged of its quota of $500,000. Nearly 20,000 of our members are yet to be heard from. Are *you* one of these? It is important to get this job done this year. Checks should be made payable to United Engineering Trustees and are tax-deductible—or you may pledge now and pay later.

Where We Stand

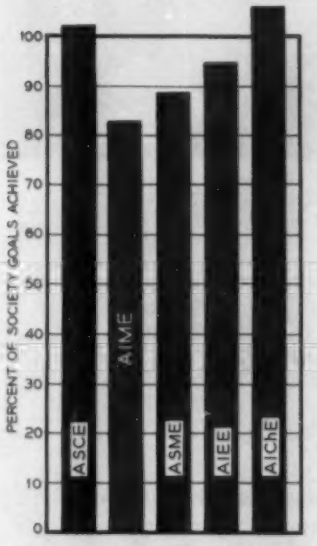
AIME Local Sections have been advised that returns from members who have made pledges should be completed by Dec. 31, 1960. Twenty Local Sections have now (November 9) attained their goals, and 34 others have less than $1000 to raise, as shown by the table at the left. This table also shows that in the Sections that have met or exceeded their quotas, an average of 43 pct of their members have contributed, whereas of the 41 Sections that have $640 or more to raise, only 17 pct of their membership has pledged. Inasmuch as the chart and table show that acceptance of professional responsibilities, and generosity in supporting a most important cause are not matters of geography among our members, it seems evident that, for the most part, members in the lagging Local Sections have not been personally approached.

What You Can Do

If your name is conspicuous by its absence from the list, you can remedy this before the end of December by sending in your pledge to your Local Section Chairman or Secretary, without further solicitation. And, better yet, offer to help your Section officers in raising the necessary money to meet the Section's quota. A few personal calls, or phone calls, are all that are necessary for many of the Sections to attain their targets.

The United Engineering Center, housing AIME headquarters, is being erected to serve you. When it is completed, you will be proud to know that you have contributed.

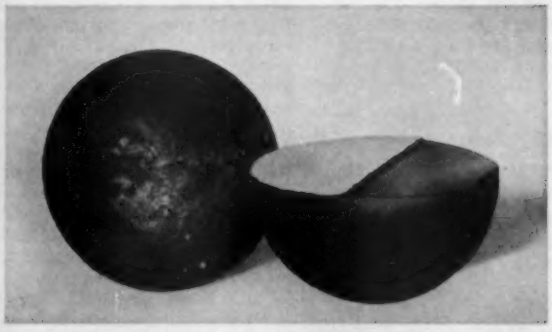
How is AIME Doing?



United Engineering Center Building Fund Member-Gifts Campaign, Status as of Nov. 1.

Work is progressing nicely on the new United Engineering Center as can be seen below. AIME will occupy the 13th and 14th floors of the building located at United Nations Plaza and 47th St. in New York.

New steels are born at Armco



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OFFICE OF THE SECRETARY

Dear SME Member:

In February 1960 your SME Board of Directors, acting on recommendation of the Society's Editorial Board, took another step toward a fully integrated publications policy for the society. Announcement of this action appears on the other side of this sheet.

The first step was the establishment of the SME Preprint Program. This has been increasingly successful. Complete success will be attained when each author of an Annual Meeting paper and each author of a paper presented at other meetings sponsored by SME supplies us with a copy of his paper for preprinting.

Preprints make available to you and to every other member, immediately upon presentation of a paper, all the information it contains.

Immediate publication as a preprint makes it unnecessary to publish transactions papers in MINING ENGINEERING prior to their appearance in the Transactions Volume. This frees the pages of the magazine for more articles of timely interest.

Some of these articles will have been meeting papers. Others will be written expressly for MINING ENGINEERING. Publication in the magazine does not rule out consideration for Transactions.

Finally, those papers considered by the Committee as of timeless interest will be preserved for the archives of the industry in the Transactions Volume.

It is believed that this sequence presents an integrated publications program for the SME membership because:

1. It makes immediately available all important data brought out at technical meetings sponsored by the Society.
2. It makes MINING ENGINEERING a better, more comprehensive vehicle for articles of timely interest.
3. It preserves in the Transactions Volume those data considered by competent authorities as of timeless interest.

Turn to the other side of this sheet to read the important announcement about the new Transactions Volume.

Jack Fox

A CONSTITUENT SOCIETY OF THE AMERICAN INSTITUTE OF MINING, METALLURGICAL, AND PETROLEUM ENGINEERS

TURN THE PAGE FOR FURTHER DETAILS

AVAILABLE IN EARLY JANUARY 1961 . . .

AIME TRANSACTIONS VOL. 217 (Society of Mining Engineers)

The new and expanded Mining Transactions volume will be available early in January 1961. This volume will contain over 300 pages of material never before published. Use the handy blank at the bottom of this page to order your copy of Volume 217 if you have not already done so. A tentative list of the contents follows.

Price: $7.50, soft covers (AIME Members only) **$8.50, hard covers (AIME Members)**
$12, hard covers (Non-members, add 50c for foreign orders)

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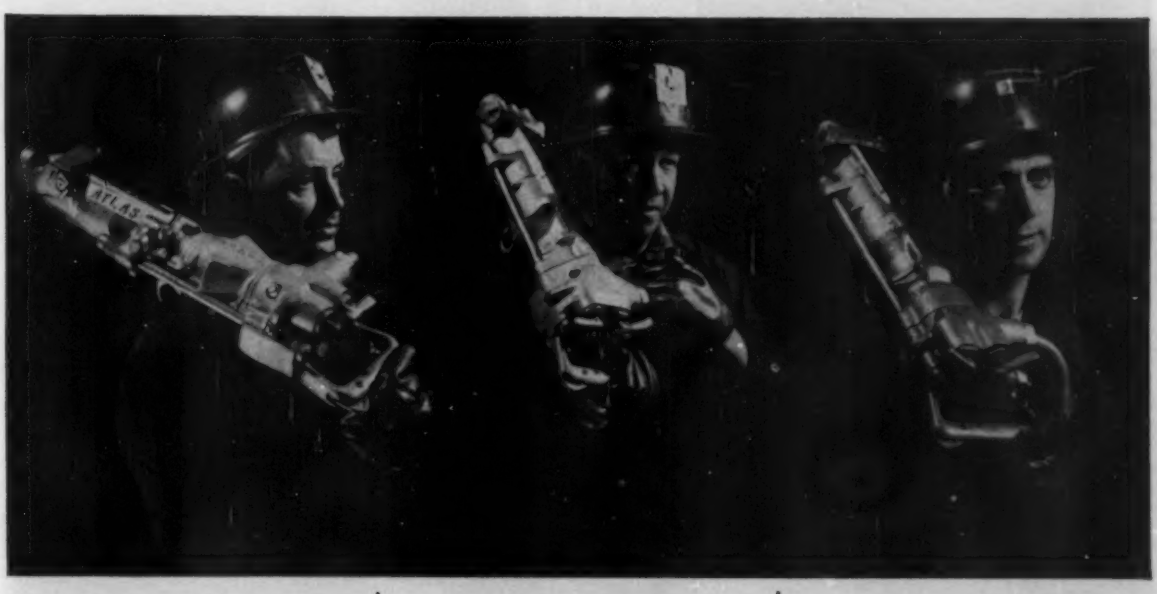

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MINING engineering **DRIFT**

ABSTRACTS FOR SME'ERS

On page 1239 you will find the beginning of what is destined to be the *Abstract Booklet* of the Society of Mining Engineers of AIME for the 1961 Annual AIME Meeting in St. Louis, Mo., February 26 through March 2.

Headquarters for the Convention will be the Chase-Park Plaza Hotels. This hotel will also house all SME sessions and social events, the AIME Welcoming Luncheon, Informal Dance, and the Annual Banquet of the Institute.

We call your attention to the Abstract Section of this issue because we are proud of it and those members who helped make it possible. Even where the abstract of a particular paper may be missing, you can be sure that several members wrote, wired, and telephoned the author in an effort to get him to submit his abstract in time for its inclusion in this issue. There may have been a variety of good reasons why he couldn't comply. The point is, each year more authors are meeting our publication deadlines so that you can have a comprehensive preview of the coming Annual Meeting.

We all owe a debt of gratitude to the Program Committee and to the speakers they have lined up—to the former for the well thought-out programs they have provided, to the latter for the hearty substance they have imparted to the programs.

We'll see you all in St. Louis.—*John C. Fox.*

SME PREPRINTS FOR THE 1961 MEETING

Continuing SME's successful Preprint Program is, of course, a **must** for the 1961 St. Louis Annual Meeting, and the staff is hard at work preparing the new *stock*. A list of available Preprints will be published in an early 1961 issue of MINING ENGINEERING and Preprints will be distributed at the Annual Meeting.

In order to expedite handling of your Preprint order, please **do not order** until the *Available* list appears. Only those papers numbered on the list will be available.

AND ITS DECEMBER AGAIN!

• As December rolls around again, the staff of MINING ENGINEERING and the Society of Mining Engineers want to thank all who have helped make our year a successful one.

TO the hardworking committees: Society, editorial, meetings, Local Sections,

TO those who have helped produce our monthly: printer, suppliers, engraver, artists,

TO everyone who contributed to each issue,

AND especially to our authors without whom the magazine would not exist,

we want to extend all best wishes for the Holiday Season and the coming New Year.—*The Staff.*

RIPPING WITH D9 ELIMINATES SHOOTING SANDSTONE AT THIS MODERN STRIP MINE

Expensive, time-consuming blasting of overburden is a thing of the past at the Harrisonville, Ohio, strip mine of the Swisher Coal Company. Caterpillar D9 Tractors with No. 9 Rippers loosen the sandstone overburden, which is then removed by a fleet of Cat DW21 Tractors, pushloaded by D9s.

In addition to saving the cost of shooting, the Pomeroy, Ohio, company saves the cost of reclamation. DW21s spread the excavated overburden over a large area, eliminate spoil banks entirely. The overburden averages 50 feet, covers a 2-foot coal seam. Production at the mine averages from 1000 to 1200 tons daily.

D9 Tractors with No. 9 Rippers pay big dividends on modern stripping operations. (1) They save time and expense of blasting; (2) reduce wear and tear on loading equipment; (3) eliminate troublesome chunks; and (4) they are versatile—can build roads, clean up and handle other utility jobs.

And now the "King of the Crawlers" is even more rugged, more powerful! The new D9E has a massive new undercarriage that adds hours of life to running gear. A new Caterpillar-developed steel alloy strengthens links, shoes, rollers up to 40%. And the mighty new D9 packs 335 HP in its Turbocharged Engine.

Get the whole story from your Caterpillar Dealer. The new D9E is now available with revolutionary new torque divider power shift transmission. Ask for a demonstration on your stripping operation; you'll see more profit in every pass.

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NEW D9E—
BORN OF RESEARCH
PROVED IN THE FIELD

Annual Meeting Program and Abstract Section

Calendar of Events

SME sessions, AIME sessions of interest to Society Members, and social events at the AIME Annual Meeting in St. Louis, February 26—March 2, 1961.

All events listed below are at the Chase-Park Plaza Hotels.

Saturday

AIME Council of Section Delegates,
10:00 am-5:00 pm, Zodiac Room

Sunday

SME Program Committee,
9:00 am-5:00 pm, Hunt Room
AIME Board of Directors,
2:00-5:00 pm, Regency Room
SME Education Committee,
2:00-5:00 pm, Zodiac Room
AIME Council of Education Social Hour,
5:00-6:00 pm, Zodiac Room; Buffet Supper, 6:00-7:00 pm, Starlight Roof; Meeting, 8:00-10:00 pm, Zodiac Room

Monday

SME Authors' Coffee Hour,
8:45—9:15 am, Regency Room,
SME Board of Directors,
9:30 am-12 m, 2:30-5:00 pm, Hunt Room
SME Education Committee,
9:30 am-12 m, Swedish Room
Coal Symposium on Froth Flotation,
9:30 am-12 m, Zodiac Room
M&E Open Pit Mining,
9:30 am-12 m, Chase Club
IndMD Mineral Aggregates,
9:30 am-12 m, Regency Room
MBD Crushing and Grinding,
9:30 am-12 m, Starlight Roof

AIME Welcoming Luncheon,
12:15-12:15 pm, Khorassan Room

Coal Preparation Plant Design,
2:30-5:00 pm, Zodiac Room
M&E Underground Mining,
2:30-5:00 pm, Chase Club
IndMD Fillers, Fibers, and Pigments,
2:30-5:00 pm, Regency Room
MBD Concentration,
2:30-5:00 pm, Starlight Roof
AIME Social Hour, 6:00 pm, Exhibit Area; Dinner-Smoker, 8:00 pm, Khorassan Room

Tuesday

MBD Scotch Breakfast, Business Meeting,
7:30-10:00 am, Chase Club
SME Authors' Coffee Hour,
8:15-8:45 am, Regency Room
SME Mining Engineering Educators' Subcommittee Breakfast Meeting,
7:30-10:00 am, Park Room
Coal Materials Handling,
9:00 am-12 m, Zodiac Room
M&E Research Symposium,
9:00 am-12 m, Khorassan A Room
IndMD Industrial Waters,
9:00 am-12 m, Regency Room
MBD-EMD Chemical Process,
9:00 am-12 m, Starlight Roof

Council of Economics Luncheon,
12:15-2:00 pm, Lido Room
IndMD Luncheon,
12:15-2:00 pm, Chase Club
Coal Division Luncheon,
12:15-2:00 pm, Zodiac Room

Tuesday (cont.)

AIME All-Institute Session,
2:30 pm, Khorassan C Room
AIME All-Institute Business Meeting,
4:30-5:00 pm, Khorassan C Room
Coal Division Open Business Meeting,
4:30-6:00 pm, Georgian Room
IndMD Business Meeting,
4:30-6:00 pm, Park Room
SME Dinner,
7:00-10:00 pm, Starlight Roof
AIME All-Institute Informal Dance,
9:00 pm-1:00 am, Khorassan C Room

Wednesday

SME Authors' Coffee Hour,
8:15-8:45 am, Regency Room
Coal New Developments in Midwestern Coal Mining, 9:00 am-12 m, Zodiac Room
M&E-SEG Geology and Management,
9:00 am-12 m, Khorassan C Room
IndMD Conflicting Interests in Exploitation of Industrial Minerals, 9:00 am - 12 m, Regency Room
MBD Materials Handling and Mill Design,
9:00 am-12 m, Tiara Lounge South
MBD-ISD-EMD Basic Symposium on Kinetics and Design, 9:00 am-12 m, Starlight Roof

M&E Luncheon,
12:15-2:00 pm, Chase Club
M&E Jackling Lecture,
2:00 pm, Khorassan C Room

Coal Symposium on Underground Mining,
2:00 pm, Zodiac Room
Coal Safety and Ventilation,
2:00 pm, Stockholm Room
IndMD Raw Materials for Chemical Industries in the Midwest, 2:00-5:00 pm, Regency Room
MBD Materials Handling and Mill Design,
2:00-5:00 pm, Tiara Lounge South
MBD-ISD-EMD Basic Symposium on Kinetics and Design, 2:00-5:00 pm, Starlight Roof
M&E Business Meeting,
4:30-6:00 pm, Hunt Room
AIME Annual Banquet and President's Reception,
7:00 pm-1:00 am, Khorassan Room

Thursday

SME Authors' Coffee Hour,
8:15-8:45 am, Regency Room
Coal Utilization, Gasification, and Carbonization,
9:00 am-12 m, Zodiac Room
M&E Geochemical Session,
9:00 am-12 m, Khorassan A Room
IndMD—Council of Economics Transportation of Bulky Minerals, 9:00 am-12 m, Regency Room
MBD Solid Fluid Separation,
9:00 am-12 m, Starlight Roof

MBD Luncheon,
12:15-2:00 pm, Chase Club
SEG Luncheon,
12:15-2:00 pm, Tiara Lounge

Coal Field Trip to River King Mine,
2:00 pm
M&E Geophysics for the Geologist and Engineer,
2:00-5:00 pm, Khorassan A Room
MBD Operating Control,
2:00-5:00 pm, Starlight Roof
MBD-EMD Pyrolysis and Agglomeration,
2:00-5:00 pm, Zodiac Room

- Coal Division, pages 1240-1241.
- IndMD, pages 1241-1244.
- MBD, pages 1244-1247.
- M & E Division, pages 1247-1249.
- Council of Economics, pages 1243-1244, 1249.

SOCIETY OF MINING ENGINEERS

1961 ANNUAL MEETING PROGRAM

This Section outlines the Technical Program for sessions sponsored by the Society of Mining Engineers and its Divisions. Titles of all papers are listed under Division headings according to the time and order of presentation at the 1961 Annual Meeting. All abstracts received by the October 20 deadline are included in the following pages. An Available Preprint List, by number, will be published in a subsequent issue. **Do not order until this list appears.**

COAL DIVISION

Symposium on Froth Flotation

Monday, February 27
9:30 am, Zodiac Room
Co-Chairmen: Martial P. Corriveau, Wendell E. Bearce

Economic Justification for Froth Flotation by *James W. Miller.*

Handling of Ultra-Fines in Germany by *Karl Sallmann.*

Froth Flotation in Durham Division of the National Coal Board by *H. MacPherson.*

Continuous Filtration and Thickening of Coal Flotation Concentrates and Tailings by *L. Dale* and *D. A. Dahlstrom.*

Coal Preparation Plant Design

Monday, February 27
2:30 pm, Zodiac Room
Co-Chairmen: Frank Zachar, F. P. Calhoun

Design of the Loveridge Mine by *H. A. Washburn.*

Design of the Thunderbird Plant by *James J. Merle.*

Design of the Old Ben Mine No. 21 by *J. W. McDonald.*

Materials Handling

Tuesday, February 28
9:00 am, Zodiac Room
Co-Chairmen: James P. Blair, H. E. Steinman

Material Handling Aspects of Fine Coal Preparation by *E. V. Bowman.*

Reject and Slime Disposal at Maple Creek Preparation Plant by *Leslie U. Anderson.*

Maximum Profits from Coal Preparation Plants through Linear Programming by *Fred D. Wright*—Production of a coal preparation plant is governed by many restrictions such as the tonnage of different products and blends that can be sold within a given period, capacities and output proportions of the cleaning and sizing units, blending proportions, quality specifications, and costs and prices for the various products. Determination of the tonnage of each product and blend that should be made in order to obtain the maximum profit can be difficult unless a systematic method such as linear programming is used.

This paper discusses briefly the basic method of linear programming. Old Ben No. 9 preparation plant is described to illustrate in detail how equations can be written to form a linear programming model of a coal preparation plant. Three sample problems, each requiring 56 or more equations and 63 structural variables, were solved on an IBM 650 computer.

New Developments in Midwestern Coal Mining

Wednesday, March 1
9:00 am, Zodiac Room
Co-Chairmen: H. E. Mauck, F. D. Wright

River King Coal Mine by *W. A. Weimer*—The River King mine in Freeburg, Ill., was conceived by the management of two coal companies, Peabody Coal Co. of Chicago and Sinclair Coal Co. of St. Louis. The idea of this mine culminated in the merger of these two companies. Although the River King mine was located to serve the mining of 200,000 tons of underground coal, it has been operated as a strip mine for the past four years. The 70-cu yd shovel has moved record yardages but has a limited stripping depth range. A Bucyrus excavating wheel has recently been added to increase the volume and, more important, the stripping depth at this mine.

The mine is located 30 miles from the river loading dock in East St. Louis and is served by a company-owned railroad. An affiliated barge company makes this venture an integrated mining company to produce and transport coal from the mine direct to the customer. Several innovations have been introduced in operating this new modern mine; one significant development has been a railroad car haul whereby a trainload of cars are loaded, coupled on each level track, and handled by one man.

Adaptability of Illinois Coal for Use in Iron and Steel Production by *Hubert E. Risser*—The past 15 years have seen a marked growth in the use of Illinois coal for production of metallurgical coke, chiefly for the following reasons: 1) Research and experimentation have shown that satisfactory blast furnace coke can be produced by proper blending of Illinois coal with more strongly coking coals. 2) Improved preparation has enabled Illinois coal producers to reduce undesirable impurities and improve the uniformity of their product. 3) The combination of easily mined coal seams and proximity to market have given Illinois coal an economic advantage in competing in the midwestern market. Figures show that with respect to mining and transportation costs and unmined reserves, this economic advantage has been steadily increasing.

The declining availability and rising costs of coking coals from traditional sources will give further impetus to this trend. Recent technological trends in the steel industry promise to strengthen the coal industry of Illinois even more.

Requirements and Advantages of an All-Belt Mine Haulage System by *William J. Orlandi*—Explanation of the selection and development of all-belt haulage system to handle production of 4½ million tons annually. Slides will illustrate installation and functioning of haulage system.

Symposium on Underground Mining

Wednesday, March 1
2:00 pm, Zodiac Room
Co-Chairmen: H. C. McCollum, Ernest M. Spokes

Continuous Mining in the Pittsburgh Seam by *Martin Valeri*—Operations at Nemacolin are in the Pittsburgh seam, which ranges in height from 78 to 84 in. An advance and retreat mining system is used in the same panel. Butts are driven to a depth of 2400 ft with entries and crosscuts 14 ft wide, on 100-ft centers. Top coal and drawslate are held in place to get a better product (lower sulfur) from the cleaning plant. A loop system of 40-lb track is used to service the machines with 7-ton cars. Loading points are moved every 200 ft. Main mining units are Joy 1 CM ripper machines. Equipment for one section is composed of one continuous miner, one pickup loading machine, three shuttle cars, and a car spotter. The crew consists of six men and a foreman. Latest machine in service is the Joy 6 CM, which is used in retreating blocks of coal 86 x 86 ft in area. Power is supplied by a 600-kw motor generator set on the surface. Voltage is 250 dc at the machine. Average load is 600 amp. Average production over one year is 575 tons per shift.

Continuous Mining in Seams Less than 38 In. Thick by *K. S. Hobbs.*

Full-Dimension Mining by *R. H. Jamison, Jr.*—This paper deals with the use of full-dimension face transportation. First the term *full dimension* is briefly defined. Then, to develop a clearer picture of the need for this type of transportation by Delmont Fuel Co., mining conditions at the company's properties are discussed. A description is given of the equipment, stressing the operational rather than the mechanical characteristics. This is followed by a discussion of the use of *full dimension* as applied to Delmont's operations with conventional preparation equipment and continuous mining machines. The paper concludes with another consideration of the equipment and how it has benefited production at Delmont Fuel Co.

Safety and Ventilation

Wednesday, March 1
2:00 pm, Stockholm Room
Co-Chairmen: James B. Benson, Benjamin H. Schull

Use of Sonic Techniques in Exploring Coal-Mine Roof Strata by *Thomas C. Miller* and *Charles E. Morgan, Jr.*—The problem of roof control in the coal mining industry is a major one inasmuch as 65 pct of all coal-mine fatalities result from falls of roof, face, or ribs. The U.S. Bureau of Mines has instituted an investigation to determine whether sonic techniques can be applied successfully to explore mine roof conditions not readily discernible by visual inspection. Theory and actual experiments indicate the practicability of exploring coal-mine roof strata through the use of sonic techniques and tests in the experimental mine confirm the validity and usefulness of the method. However, much more work is required on design details to meet the need for lighter and more compact apparatus and for equipment suitably designed for use in a mine having gas or a dusty environment.

Use of Foam Plug in Controlling Mine Fires by *William Parisi.*

Control Mine Fans and Substations in Case of Fan Failure by *J. A. Boyle* and *O. S. Conn.*

Utilization, Carbonization, and Gasification

Thursday, March 2
9:00 am, Zodiac Room
Co-Chairmen: Andrew H. Brisse, C. F. Hardy

(Thursday afternoon, March 2, field trip to River King mine, Peabody Coal Co.)

Bench-Scale Experiments on Low-Temperature Carbonization of Lignite and Subbituminous Coal at Elevated Pressure by *W. H. Oppelt* and *W. R. Kube*—Five low-rank coals, including two lignites, a steam-dried lignite, and two subbituminous coals, were carbonized at 940°F, in a bench-scale carbonizer with a nitrogen and/or hydrogen atmosphere, under pressures ranging from atmospheric to 1000 psig. Coking characteristics were observed and yields, composition, and distribution of products from thermal degradation were determined.

Know Your Coal by *J. T. Peters* and *N. Shapiro.*

Gasification of Solid Fuels in the Wellman-Galusha Gas Producer by *George M. Hamilton*—In Europe and the U.S., steady improvement in design of the gas producer has increased capacity, efficiency, and flexibility and has improved automation. The paper discusses: 1) the reactions when replacing straight air blast with 100 pct oxygen, to yield high-percentage carbon monoxide and hydrogen gases; 2) the reaction when straight oxygen with carbon dioxide is used in the blast to produce high-percentage carbon monoxide; 3) the gas producer's versatility when gasifying anthracite, bituminous coal, or coke, as applied to a variety of industries around the world.

Coal Gasification for Production of Synthesis and Pipeline Gas by *Martin A. Elliott.*

Design and Preliminary Operation of a Slagging Fixed-Bed Pressure-Gasification Pilot Plant by *W. H. Oppelt* and *G. H. Gronhovd*—An important approach to use of lignite is gasification to produce gas for the manufacture of synthetic chemicals and fuels. To investigate lignite gasification, the design of a fixed-bed pressure-gasification pilot plant to be operated under slagging conditions is described. Results are presented for initial operation of the plant at moderate pressure, using low-temperature char as fuel.

INDUSTRIAL MINERALS DIVISION

Mineral Aggregates

Monday, February 27
9:30 am, Regency Room
Chairman: C. E. Golson

Small Changes in Aggregate Processing Produce Real Dividends by *LeRoy Kienitz*—This article lists a number of changes and uses of various equipment in producing improved operating results.

New Developments in Screening Aggregates by *W. L. Price.*

Application of Metallurgical Principles, Processes, and Equipment to Production of Mineral Aggregates by *C. E. Golson* and *D. E. Newton*—A survey of the metallurgical principles, processes, and equipment which have been adapted to and used in the preparation and beneficiation of mineral aggregates. Main headings are: Crushing and Grinding; Screening and Scrubbing; Washing and Classification; Heavy Media Separation; Jigging; Desliming.

Foreign Trade Aspects of Fillers, Fibers, and Pigments

Monday, February 27
2:30 pm, Regency Room
Chairman: H. L. King

Domestic and Foreign Paper Fillers by *R. H. Hubbell, Jr.*, and *Albert J. Mueller.*

The Role of Organic and Inorganic Fibers in Gaseous and Liquid Filtration by *T. M. Jackson* and *R. K. Jones.*

Perlite—A Review by *Richard Barnes.*

Synthesis of Inorganic Silicate Fillers and Filter Aids by *L. R. Blair.*

Industrial Waters

Tuesday, February 28
9:00 am, Regency Room
Chairman: R. J. Kazmann

Water: Its Role in Mining and Beneficiating Iron Ore by *Orville D. Mussey.*

Our Future Water Needs: Comparison of Paley Commission and RFF Projections by *Nathaniel Wollman*—Results emerging from a study now in progress indicate that in making projections of water use to 1975, the Paley Commission has substantially underestimated future growth in water demand. Part of the difference is explained by the lower rates of population and industrial growth assumed by the Paley report; part of the difference lies in a more accurate measure of current water use, based on facts not available to the Paley Commission staff. Estimated undercount of current water use in the Paley report apparently amounted to about 15 pct. By 1975, as compared with the middle projection of the current study, Paley Commission figures would be 25 pct less for municipal use, 32 pct less for agriculture, and 32 pct less for industry. By 1975 under-projection of basic economic magnitudes, relative to middle projections of the current study, would be 14 pct for population, 17 pct for GNP, and 27 pct for industrial production. The current study also seeks to measure water requirements for on-site and flow uses and to distinguish between gross (or intake) requirements and depletion, i.e., evapotranspiration requirements. Flows for waste dilution are also systematically incorporated into measures of need. Regard for these additional aspects of water use necessarily causes further differences in magnitudes of projected demand.

Saline Water Conversion Economics by *V. C. Williams*—The economics of some physical, chemical, and electrical processes for converting saline water to potable or industrial water are surveyed from an engineering viewpoint. Since all these processes require energy for drive and equipment for containment, the author discusses economic factors which influence the choice of process to be used in any given region. This choice is also affected by the supply and accessibility of natural waters. Probably no one process will prove dominant, since decisions concerning initial and operating costs are obscured by other factors—the saline source; types and continuing availability of fuel; electric power use or recovery; economic status and advancement of the area; and the political pressure of population, group demands, and land. Basic engineering considerations, data, and economic comparison factors are presented to assist in guiding these decisions.

Aruba Depends on Sea-Water by *Oscar S. Henriquez*—Rainfall on Aruba averages a scant 20 in. annually; there are practically no wells, since ground water is too brackish to be used for drinking or agriculture. Before the huge oil refinery that is Aruba's main industry was established, the sparse population got its water from the few brackish wells and from rainwater cisterns. A 600,000-gpd sea-water distillation plant built in 1932 met the island's domestic water needs. This fresh water, produced at a cost of about $1.25 per ton, was distributed at about $0.90 per ton to bring the price within the economic means of the island's population, but to the local government this meant an annual loss of $250,000, excluding amortization.

The new $10 million plant completed in April 1959 is the world's largest and most efficient sea-water conversion unit, with capacity of 2.7 million gpd of fresh water. At the same time this unit can generate 12,500 kw of byproduct electric power daily at full capacity, out of the 15,000 kw of installed capacity. The plant will more than meet the potable water needs of the 57,000 inhabitants of Aruba, at less than half the previous cost, and the local government is now selling water to the oil refinery at a price on a par with the cost previously incurred by the refinery in recovery of its own water. Research work is being extended in Aruba on the possibility of recovering salt economically from the brine, which now flows back into the sea. From the sodium-chloride, caustic-soda and chlorine (both basic chemicals for certain industries) could be produced electrolitically, using the byproduct electricity.

Water Use in the Mineral Industry by *R. T. MacMillan*—The USBM included several questions on water use in the 1959 general information questionnaire sent annually to all U.S. producers of minerals other than fuels. Data were collected on the total water required for various segments of the industry, the quantity recirculated, and the treatment, if any, required. Results of this study were tabulated by states and water-use regions.

Differences between the water-use data of the U.S. Bureau of Mines and U.S. Bureau of the Census are discussed. In collecting and interpreting data it was found that many respondents did not fully comprehend the water problem, differed as to measuring units, and disagreed on what constitutes recycling.

Conflicting Interests in Exploitation of Industrial Minerals

Wednesday, March 1
9:00 am, Regency Room
Co-Chairmen: R. J. Lund, Leon M. Dupuy

Introduction by *Orris C. Herfindahl.*

Urbanization and the Mineral Industry by *Harold B. Goldman*—Producers of low-cost commodities—such as clay, crushed stone, sand, and gravel—are being crowded out of existence by urban growth. When natural resources are no longer readily available, raw materials are imported at additional expense.

The diverse uses of land for agriculture, recreation, and residential and industrial development can be integrated with mining. Careful mining operations can often result in the creation of valuable building sites and recreation areas. Long-range planning can help conserve our mineral deposits for future exploitation, but civic officials must inform themselves of mineral wealth within their jurisdiction by seeking assistance from state and federal geologic surveys, consulting geologists, and mining engineers. Planning and zoning should be used to set aside mineral lands and to set up requirements for their proper exploitation.

Highways as Competitors in Usage of Land for Mining and Quarries by *Ralph J. Bernhagen*—Our exploding population growth demands more land in urban areas and better means of transportation. The author presents case histories to show how construction of highways has interfered with operations of the mineral industries and tells how conflicts have been resolved. The most critical competition, however, has occurred adjacent to large municipalities or within corporate limits. When individual situations are evaluated, the whole complex of metropolitan growth must be taken into consideration.

Quarrying or Mining Vs Water Reservoirs by *Thomas Maddock, Jr.* A reservoir is one aspect of water resource development that may conflict with other types of resource development. There is no satisfactory procedure in this country for evaluating and making a selection from competing forms of resource development. Congress is the body which in the long run decides on the nature of resource development in this country. As between reservoirs and mining developments there is opportunity for compromise in selecting measures that will permit both mining and reservoir operations.

Mining vs Public Land Withdrawals by *Hollis M. Dole*—Withdrawal of public land from mining has been accelerated during the past 15 years, and no let-up is in sight. Following World War II, millions of acres were withdrawn for military use. Since 1950, in every western state, mining has been excluded from public land withdrawn for the stated purpose of preserving recreation or wilderness sites for the future. Governmental agencies having control of land or serving the recreational pursuits of the public appears to be in a competitive race on withdrawals.

Legislation enacted during the 1950's has brought military withdrawals under better control of Congress, opened power site withdrawals to mining, and established simultaneous use of land for lease and locatable minerals. But it has also restricted the use of the surface of claims by the miner, left management of all surface nonmineral resources on new mining claims in the hands of the Federal Government, established procedures for bringing the surface management of old claims under Government control, and reduced the number of minerals that are locatable.

Minerals and materials extracted from the ground create wealth and are absolutely essential to the maintenance, development, and progress of the world's economy. Inasmuch as laws in force today already provide for both multiple surface use of land and subsurface extraction of materials from that land with a minimum of conflict, withdrawals should be restricted to local spots of unusual interest and places having large capital investments, such as ranger stations, improved camp sites, and hotels.

Raw Materials for Chemical Industries in the Midwest

Wednesday, March 1
2:00 pm, Regency Room
Chairman: W. M. Zilbersher

Rock and Mineral Chemical Raw Materials in the Midwest by *Thomas R. Beveridge*—Paper outlines types and geographic distribution of the various rocks and minerals of the Midwest that are used as chemical raw materials. Development of these materials depends partly on the research activities of state geological surveys regarding the chemical and physical properties and stratigraphic and geographic distribution of rocks and minerals in the respective states. Very few state surveys have had the funds and personnel to do such research. Ideally, these data should be available on all

the rocks and minerals in a state, since what is valueless today may be valuable tomorrow.

One of the most neglected fields in the mineral industries is beneficiation of the low-value nonmetallic rocks such as limestone. The failure of nonmetallic beneficiation studies to keep pace with metallic beneficiation research is in part the result of academic curricula which tend, in many schools, to neglect the nonmetallics.

Rock Salt Mining and Economics in the North Central Area by *W. C. Bleimeister*—Rock salt of Silurian age occurs in Ohio, Michigan, and southern Ontario. The deposits are flat-bedded, vast in extent, high in quality, close to major markets, and the source of about two-thirds of the total rock salt mined in the U.S. The rock salt mines of the U.S. are the largest producers in the world. Mines vary in depth from 600 ft in Kansas to 1700 ft in Ontario. Modified coal mining techniques and equipment are used, the rock salt being harder than coal. Mining is under ideal conditions, as explosive gases, water, and unstable ground are absent. Roofs are self-supporting; rooms are large; the product is clean. Four grain sizes are produced for marketing. Handling and transportation by rail, water and truck present distribution problems. Approximately 75 pct of the rock salt produced is used as a chemical raw material, primarily for making chloride and caustic soda. These are utilized in turn to make other chemicals of greater versatility. Other uses are in meat packing and foodstuff production, tanning, refrigeration, animal husbandry, water softening, and ice removal from highways.

Chemical and Metallurgical Limestone in Northern and Northeastern States and Ontario by *Kenneth K. Landes*—About three-fourths of the total output of chemical and metallurgical limestone from this north central—northeastern area comes from Michigan, Pennsylvania, Ohio, and Ontario (the leading source in Canada). The north central and northeastern states supply more than half the U.S. annual output; most of the remainder comes from New York, Missouri, Illinois, and Iowa.

The specifications, physical and especially chemical, for chemical and metallurgical stone depend on the end use, but in general the tolerance for impurities is so low as to rule out most limestones and dolomites. Both high-calcium limestone and dolomite are used in the metallurgical industries, principally as a flux in iron ore blast furnaces and open hearth steel furnaces, and in the chemical industries, chiefly in lime burning and soda ash manufacture. They are also important in glass manufacture, calcium carbide production, and sugar refining.

All deposits of high-quality carbonate rock are finite. Inevitably they become so diminished laterally, either in thickness or in quality, as to be unworkable as chemical and metallurgical stone. These high-quality lenses range in size from a few thousand tons to hundreds of millions of tons. Best possibilities for new supplies are the geologic formations known to contain premium-quality deposits. However, because of high transportation costs, carbonate rocks, to be economically workable, must be close to market.

Lithium Horizons by *Louis J. Czel* and *W. F. O'Brien*—Despite recent slowdowns, the domestic lithium industry continues on its upward trend. Major delaying factors have been the termination of Atomic Energy Commission contracts, which resulted in overproduction of certain lithium compounds; fluctuating prices; and lack of an adequate commercial market. Renewed interest in lithium chemicals for rocket propulsion and wide acceptance of lithium-aluminum alloys may stimulate the industry to new rapid advances during the years to come.

Foreign lithium producers, such as Bikita in Southern Rhodesia, create a decided effect on the industry by supplying a variety of lithium ores to manufacturers of ceramics, glass, lithium chemicals, etc. Although known domestic reserves are more than adequate to meet present demands, high-grade ores from abroad are in demand. Consequently Bikita is the Free World's leading producer of petalite and lepidolite and a formidable competitor to domestic producers.

Transportation of the Bulky Industrial Minerals (Joint with Council of Economics)

Thursday, March 2
9:00 am, Regency Room
Chairman: Paul H. Hedley

Transportation Economics of Mineral Commodities by *William A. Riggs*—In the mining, processing, and marketing of solid mineral commodities, transportation is the greatest single cost item. For the annual volume—in the magnitude of 1¾ billion tons—cost of transportation is in the magnitude of $5 billion. About one third of this transportation is provided by railroads at published rates; the remainder is provided by highway, pipeline, and water carriers at both negotiated and published rates.

To the small mineral producer these rate structures often appear to be as complicated as the nation's tax laws, but those who understand the principles of traffic management can apply them to economic advantage. Generally it seems to mineral producers that their transportation costs are high as compared to the dollar value of their product. This problem appears in a very different light when it is considered in terms of the tremendous volume of ton-miles of transportation involved. Typical examples of published rates and reported costs on transportation of various mineral commodities are given and reduced to a ton-mile basis. These examples cover all types of carriers in various sections of the U.S.

Transportation of Minerals in Northern Canada by *Amil Dubnie*—The present mineral production of the Canadian north, that is, north of latitude 55° N, amounts to about 6 pct of the Canadian total. Geological conditions are comparable to those in the remainder of Canada, but the area which is considered as north occupies more than half the country.

Facilities for transport of mineral products are now available in the form of inland and coastal water, rail, road, pipeline, and aircraft, but most of the area involved has adequate air transport only. Inland water transport is handicapped by the climate. Air transport is too costly for large-scale movement of minerals. Extensive pipeline systems do not appear practical, as the products to be moved will probably be solid concentrates.

Of the major forms of transport which are applied or might find future application, costs may run as follows: inland water, 5 to 12¢ per ton mile, rail 1 to 5¢, road 5 to 20¢ and airline 40 to 60¢. For future large-scale movement of mineral products, the choice will probably narrow down to road and rail. Of these, rail transport will probably be advantageous for large-scale operations and road transport for small-scale operations.

Long-Haul Transportation of Minerals in Canada's Far Northwest by *N. Gritzuk*—Mineral production in Canada's Northwest is handicapped by mountain barriers and by great distances from markets. Operations of United Keno Hill Mines Ltd. are 1287 miles from Vancouver and those of Cassiar Asbestos Corp. Ltd. 1357 miles. A combination of road, rail, and sea transport brings mining products of United Keno to smelters in British Columbia and Montana and carries Cassiar Asbestos fiber to Vancouver, a sales point for this product.

Weather conditions are not major factors in transportation, except for the problem of snow removal through mountain passes in gaining access to the sea by rail.

The packaging of mine products for shipment and the integration of mine supply with outbound mining products is vital in developing maximum economy in production. Transport represents approximately 30 pct of the cost of production.

Construction of the Alaska Highway and Federal development roads has been a major factor in making production from these two mines profitable. The generous loadings allowed on motor-truck transport permit long-distance road haulage at minimum cost.

Water Transportation of Fertilizer Ingredients: Opportunity and Challenge by *Odin Wilhelmy, Jr.*—A substantial opportunity, not yet fully realized, exists for increased water transportation of fertilizer ingredients, especially for moving various phosphate materials from points of production to major fertilizer-consuming centers. A similar opportunity of lesser proportions exists for water transportation of certain nitrogenous fertilizer ingredients.

Before the benefits and economies inherent in this increased water movement of fertilizer raw materials can be fully realized, certain obstacles must be overcome. The following actions appear most likely to remove the technical or economic obstacles that now hamper such water movements:

1) Development of a procedure and facilities for moving ground phosphate rock by water.

2) Alternatively, establishment of grinding facilities for phosphate rock at selected points in market areas.

3) Establishment of terminal storage facilities at selected points in market areas.

4) Development of better and more economic handling and loading methods.

5) Establishment of more joint barge-truck or barge-rail arrangements to facilitate shipments to plants not located on navigable waterways.

Some action already is being taken on these steps by forward-looking companies in both the fertilizer and transportation industries, but ultimate solution of the problems involved will require still further advances in both the technology and economics of transportation. However, the prizes for success—increased sales of fertilizer ingredients, lower delivered cost of these ingredients to the manufacturer, more business for transportation agencies, and the resultant benefits to the farmer—are worth the effort.

(Session continued on page 1244)

Economics of Five and One-Half Mile Transport Belt System at Ideal Cement Co. Plant by *Thomas B. Douglas*—Limestone and shale from Ideal Cement Co. quarrying operations at Lawrence, Okla., were originally transported by public railroad to the company plant at Ada, Okla., some six miles away. When the company decided in 1955 to build a second plant at Ada, additional facilities had to be provided for crushing and loading at Lawrence and unloading at the new and old plants. It was apparent that modern rail facilities for a five-day week would be elaborate and expensive. A comprehensive study of rail, truck, and conveyor belt transport of raw materials revealed the third method to be most economical, and the 5½-mile belt system was installed. Preliminary costs are compared with the company's original estimates.

Materials Handling, Transportation, and Packaging in the Cement Industry by *Alfred A. Roetzer*—Customer demands for bagged cement have necessitated increased truck shipments and palletized loads. This calls for innovations in packing and warehousing, new facilities for truck loading, and revised scheduling methods for efficient packaging and truck handling. The expense of these new facilities and the constantly rising costs of present packing and loading can be offset, and down time reduced, by automatic packaging, checkweighing, and palletizing; longer packing runs; warehousing of filled bags on pallets; fork-truck handling of loaded pallets; well-planned truck-loading terminals; and unit loading of filled bags in railroad cars.

MINERALS BENEFICIATION DIVISION

Crushing and Grinding

Monday, February 27
9:30 am, Starlight Roof
Co-Chairmen: F. J. Windolph, J. H. Brown

Principles and Progeny in Comminution by *Fred C. Bond*—This paper deals with certain principles of rock breakage, the particle size distribution of comminution products, and the number of particles produced with its relationship to the energy input.

The first principle states that comminution calculations should be based on the energy register, or the total specific energy resulting in breakage which has passed through the material as strain energy of all finite sizes, most of which has been converted into heat. The energy for any reduction process equals the energy register of the product minus the energy register of the feed.

The second principle states that the energy register is proportional to the crack length produced, and the third principle deals with the distribuion of flaws which are developed into crack tips by applied energy. Equations are given for the number of progeny and progenitor particles and for their relationship with the energy register.

Determination of Particle Size Distribution by X-Ray Absorption by *A. M. Gaudin* and *M. C. Fuerstenau*—A homogeneous suspension is viewed by X-rays. The radiation density seen, calculated from the data, affords a measure of the extra absorption due to the solids contained. This radiation density, at a predetermined depth, varies with time. The chart of this relationship gives the desired determination.

Kinetic Energy Effect in Single Particle Crushing by *Bert T. Bergstrom* and *Charles L. Sollenberger*—When glass spheres are crushed by slow compression loading, the outer lune-shaped fragments resulting from the fracture consistently fly outward at high velocity. At least 30 pct of the strain energy fed into the sphere-platen system reappears in the form of the kinetic energy possessed by these fragments. These measurements were obtained from high-speed photographs. This kinetic energy can be utilized for additional comminution if the fragments are allowed to impact against a suitable structure.

Theoretical and Experimental Studies of the Kinetics of Grinding in a Ball Mill by *Frank W. Bowdish*—A theoretical and experimental laboratory study has shown that the rate of breaking of oversized particles in a ball mill is proportional to: 1) the concentration of such particles and 2) the area of the balls, provided that the balls are larger than a certain size relative to the particles. Rate equations are given which are similar to those for zero, first, and second order reactions.

Concentration

Monday, February 27
2:30 pm, Starlight Roof
Co-Chairmen: E. C. Tveter, J. R. Moore

Beneficiation of Israeli Phosphate Ore by *Itzhak Hoffman* and *Burt C. Mariacher*—During the past eight years, Negev Phosphates Ltd., an Israeli corporation, has been engaged in developing a strong phosphate industry from the vast deposits in the Negev desert. The mineralogical occurrence of the phosphate and the nature of the ore have presented some uncommon problems in addition to the usual difficulties encountered in developing an operation in a remote region.

The paper describes the development of the beneficiation processes employed before the advent of water and the flotation plant recently placed into operation. The process developed is based on the more readily floated calcium carbonate, which is the major gangue constituent. Primary slime removal, sliming during the beneficiation process, and presence of salts, such as NaCl and $CaSO_4$, were among the major factors affecting beneficiation.

Concentrator Operations at Bunker Hill Co., Kellogg, Idaho by *Norman J. Sather*—Briefly summarizes milling operations at the Bunker Hill Co., beginning with 1886. Flotation at Bunker Hill dates back to 1913, when experimental work was performed in a simple cell. In 1941 the Concentrator was remodeled and modernized to improve grade and recovery of the products at a lower cost. The article outlines the use of cyclones in lead rougher flotation regrind circuit; cyclone sands go to the regrind ball mills and cyclone overflow to zinc flotation section. In the lead middling regrind, lead flotation middlings in addition to lead flotation cleaner tailings go to the cyclones, with cyclone sands going to the regrind ball mills and cyclone overflow to the lead flotation section. Regrind ball mill discharge goes to lead flotation section. The zinc concentrate is low in lead (about 1 pct) owing to the above circuit. The article describes the circuit development and flotation middling treatment, its problems and results. The distribution of metals as to recovery shows 92.8 pct Ag; 96.7 pct Pb and 23.9 pct in lead concentrate. Overall recovery of metals is 96.6 pct Ag, 97.5 pct Pb, and 89.1 pct Zn.

Esperanza Concentrator of Duval Sulphur & Potash Co. Copper Div. by *C. H. Curtis*—The Esperanza Concentrator, with designed capacity of 12,000 tpd, was placed in operation March 1, 1959, three years after the first exploratory laboratory metallurgical tests were conducted on samples from the mine development.

Detailed process flow diagrams are presented with descriptions of the notable features of procedure and equipment, which include three-stage open circuit crushing with hydro-set and hydro-cone crushers (hydraulically supported mantles); two metallurgically independent wet grinding and flotation sections each equipped with one 12.5 x 16 ft rod mill; and two 12.5 x 14 ft ball mills in closed circuit with wet cyclones. Molybdenum recovery from the combined concentrates from the two sections is achieved with pressure steaming, drying and heating, and ferro-cyanide available to the process. The molybdenum product is premium-grade molybdenum trioxide.

The extensive plant instrumentation is described under the following categories:

1) Secondary—Tertiary Crushing Circuit
2) Wet Grinding Circuit
3) Flotation
4) Tailing Thickeners
5) Molybdenum Recovery Circuit
   a) Steamer Operation
   b) Flotation
   c) Roaster

Typical metallurgical and operating performance data are presented.

Flotation of North Carolina Spodumene-Beryl Ores by *James S. Browning*—Laboratory and small-scale continuous pilot plant investigations of spodumene beryl ore from pegmatites of the Kings Mountain, N. C. area resulted in development of a new and improved method for separating and recovering the spodumene and beryl. The method comprised soap flotation of the spodumene, using combinations of sodium fluoride and lignin sulfonate as conditioning agents to recover 75 to 80 pct of the contained lithia in concentrates assaying 6 pct Li_2O. From 85 to 90 pct of the beryl was retarded in the spodumene tailing. The beryl subsequently was activated, floated, and cleaned in a secondary circuit to recover beryl concentrates containing over 6 pct BeO. The small-scale laboratory and continuous tests were encouraging enough to warrant construction of 2-tph continuous pilot plant for treating spodumene tailing from the Foote Mineral Co. operation at Kings Mountain. Results of this study will be presented in a subsequent paper.

Chemical Process
(Joint MBD-EMD)

Tuesday, February 28
9:00 am, Starlight Roof
Co-Chairmen: F. T. Davis, S. Power Warren

Characteristics of Cerium Oxide Glass Polishers by *Larry Duncan*.

Recovery of Scandium from Uranium Mill Raffinates by *Leslie D. Lash*.

Chemical Processing of Tungsten Ores and Concentrates by *K. C. Li*—The problems and limitations of milling processes are outlined. The chemical upgrading of tungsten ores and concentrates is described. The methods of extraction and preparation of pure tungstic oxide from ores and concentrates are discussed. A generalized flowsheet is given showing how impurities are removed in each step.

A Mechanism Study of the Formation of Sodium Vanadate Compounds Under Conditions of the Salt Roast Process by *William H. Dresher*.

Technique of Gas Oxidation During Pulp Agitation by *Nathan M. Levine* and *W. M. Fassell*—In this laboratory study the problem of aerative conditioning to separate chalcopyrite and pyrite from cobaltite was simply effected with a sulphydrate collector and pH by proper choice of mixing variables. It was shown that for a given impeller type and geometry, selectivity is governed by a relation between the Froude number and a "modified" power number multiplied by impeller-to-tank-diameter ratio wherein the power factor is expressed as power intensity or horsepower per unit volume of contained pulp.

In applying this approach to other systems, other criteria would be used in place of selectivity.

Basic Symposium on Kinetics and Design
(Joint with MBD-ISD-EMD)

Wednesday, March 1
9:00 am-12m; 2:00 pm-5:00 pm, Starlight Roof
Co-Chairmen: P. L. de Bruyn, R. J. Charles

Reaction in Kinetics Metallurgy by *Henry Eyring*—Because of the complicated chain of reactions which are important in such processes as corrosion or combustion many people despair of reducing the scientific studies to useful practice. Such pessimism is not justifiable. Recently we were able to prove, building on the work of Ramachandran and King, that iron smelting is an electrochemical process in which oxygen ions from the slag combine with carbon in the iron to make CO gas and leave electrons on the molten metal which combine with either sulfur which passes into the slag or with some metal atom which passes from the slag to the metal.

We have studied the transients and steady state potentials of various metal electrodes in electrolyte solutions as effected by composition of the metal, composition of the electrolyte, composition of gases present, strain of the electrode, and diffusional effects induced by stirring. This is interesting because of the light it throws on corrosion and the various catalytic processes occurring at the electrodes. The phenomena are discussed in terms of absolute reaction rate theory.

The theory of significant structures of liquids has enabled us to calculate the thermodynamic and transport properties of various liquids including surface tension. The detailed picture developed leads us to a better understanding of the abruptness of the transition between phases when only short-range forces are involved. A brief summary of other interesting results and possibilities will be given.

Mass Transfer by *T. B. King*—The importance of mass transfer in the kinetics of metallurgical reactions is examined. For solid systems most mass transfer problems can be described by fairly exact mathematical representations. Where fluids are involved, however, the mathematical description of mass transfer becomes much more complex. Theories of mass transfer in fluids, especially at fluid-solid boundaries, are reviewed and examples are given where experimental information is available. It is concluded that a generalized theory is unlikely to appear, and that particular cases are best dealt with by the principles of similitude.

Theory and Application of Model Studies by *Kun Li*—Theory of models is briefly reviewed in general terms. Three examples—ingot solidification, mixing of solids, and flotation conditioning—are given to illustrate the application of model technique. In all three cases the possibility of model approach which could be advantageously taken is not known to have been explored.

Liquid Extraction Principles and Application to Nuclear Fuel Processing by *David Miller*—The principles of solvent extraction are well known and if the equilibrium behavior is available, it is possible by simple experiments to provide the rate data necessary to design equipment.

Basic solvent extraction principles are discussed and illustrated by a new process of importance to metallurgical engineers. The use of liquid metals as extractions for metals in the solid and liquid state has attracted attention as economical means of reprocessing nuclear fuels. Such processes can retain the fuel in the metallic state, avoiding the expensive dissolution and reduction steps associated with aqueous processing or fluoride volatility processes.

Extraction of plutonium by magnesium from uranium blankets in breeder reactors and other extraction processes are illustrated by flowsheets. Problems of materials of construction and equipment design are pointed out.

Conditioning Rate Studies of an Iron Ore by *E. F. Young, Jr.*, and *John W. H. Chi*—In a new approach to the study of conditioning iron ores for flotation, an attempt was made to consider conditioning as a unit operation and establish the controlling mechanism and kinetics. Although the complete mechanism proved too complex for detailed analysis, a workable correlation of the kinetics of conditioning was developed. The use of an analog computer in evaluating kinetic constants was demonstrated.

A general type of empirical equation relating reagent level, conditioner size, agitation intensity, and conditioning time to flotation performance is presented. The empirical model is shown to be compatible with theoretical considerations.

Alloy-Salt Exchange Reactions by *A. T. Morkel* and *T. B. King*—Kinetics of the reactions of lead, zinc cadmium and tin, dissolved in bismuth, with bismuth chloride dissolved in a salt melt have been studied by direct rate measurements. It is shown that the data are consistent with rate control of the overall reaction by either the transport of the solute in the alloy or the transport in the salt melt, experimental conditions being chosen to favor one or the other of these processes. It is also concluded that the exchange reaction at the interface is fast. Since such reactions would involve the simultaneous collision of several atoms, the overall reaction probably occurs as the sum of two electrochemical partial reactions. The apparent activation energies are somewhat larger than might be expected for a purely transport-controlled process. It is also shown that the usual methods of establishing forced convection in high-temperature systems lead to diffusion boundary layer thicknesses that are relatively constant.

Kinetics of Reduction of Magnetite with Hydrogen and Hydrogen-Water Vapor Mixtures by *Jean M. Quets, Milton E. Wadsworth*, and *John R. Lewis*—Samples of synthetic magnetite were reduced at various temperatures in various partial pressures of hydrogen and in mixtures of hydrogen and water vapor. The reaction was found to be surface-controlled in all cases. In the absence of water vapor, the rate was directly proportional to hydrogen partial pressure. The reduction is believed to involve a surface reaction followed by surface diffusion to the reduced bulk phase being formed. A transition in the mechanism occurred at approximately 590°C. This has been attributed to a change in the slow step of the reduction reaction resulting from the presence of stable wustite at higher temperatures. Below 590°C the heat of activation for the reduction was found to be 14,700 cal per mole and 3200 cal per mole above. A similar mechanism is proposed for the reduction of magnetite to wustite. The retarding effect of water vapor can be quantitatively explained in terms of a back reaction involving the surface diffusing species.

Kinetics of Flotation by *O. F. Devereux* and *P. L. de Bruyn*—Studies aimed at understanding the kinetics involved in flotation have in the past consisted mainly of fitting experimental data to empirical relations. A notable exception to this approach is the theoretical analysis by K. L. Sutherland.

Dimensional analysis may also be applied to the flotation system in an attempt to obtain an empirical relation between a reduced number of dimensionless parameters. This has been done and a functional relationship relating recovery to five dimensionless groups has been obtained with the restriction that geometric similarity be observed and that the chemical conditions be invariant. Preliminary experimental studies of a simple flotation system indicate that this relationship may be of value in the scale-up of laboratory tests to plant operations.

A theoretical kinetic study is more satisfactory in that it is derived from basic principles and does not suffer from the restrictions that plague an empirical study. Flotation can be described by

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three steps: 1) collision, 2) adhesion, and 3) levitation to the froth and subsequent froth drainage. Each of these steps must be studied separately and then combined to form an expression for the rate at which the entire process occurs.

The collision rate of colloidal particles as influenced by hydrodynamic flow was treated by H. Müller. This theoretical analysis of Müller with slight modification may be applied to the collision of particles and bubbles in some flotation systems.

Adhesion of particles to bubbles may be attributed to the combined fluence of hydrodynamic forces, Brownian motion, electrical double-layer interaction, and the Londin-van der Waals forces. Preliminary calculations indicate that an analytic description of this process is possible.

No solution of the foam drainage problem has been attempted.

Materials Handling and Mill Design

Wednesday, March 1
9:00 am-12m; 2:00 pm-5:00 pm, Tiara Lounge South
Co-Chairmen: A. A. Wallach, D. G. Ashe (am)
D. O. Carlson, E. J. O'Connel (pm)

General Conditions of Mill Location and Design by *Hildreth Frost, Jr.*—Author emphasizes that plant construction, operation, and maintenance are vitally affected by factors of locale—climate, topography, water supply, political environment, and natural catastrophes. Climate is discussed according to zone (tropical, torrid, etc.); the author suggests ways to counteract the effects of intense sunshine. Prevailing winds are important. Precipitation is of vital concern.

Topography is treated in terms of building sites, road grades, housing, and natural shelter; water supply in terms of procurement, re-use, and future sources. Mineral content of the water is especially important. The past, present and, especially, the future political status in any locality is a tremendously important consideration in proposals for mill design. Natural catastrophes such as earthquakes, hail, floods, and high winds should all be taken into account and properly assessed. Although these statements seem axiomatic, past experience has shown that such factors are often neglected even on major projects, with consequent disaster and high cost.

Recent Trends in Iron Ore Beneficiation and Their Effect on Mill Design and Layout by *A. Dor*—Within the past decade, U.S. technological progress in beneficiating iron ore has been impressive along several lines of development. Many of these technological advances have led to construction of new commercial plants now in successful operation. The author compares the merits of various beneficiation flowsheets already incorporated in commercial operations or still under study for plants now being engineered and designed. He offers examples to show how design and layout of iron ore concentrators has been affected by the adoption of flowsheets recently considered for several new plants.

Economic Factors Affecting Design of a Milling Plant by *C. N. Bailey.*

Effect of Mining Operation and Tailings Disposal Requirements on Mill Design by *Robert H. Raring* and *Gilman Y. Murray*—The authors start on the note that no two installations are ever the same. Fixed rules must give way to application of basic principles. The writers discuss the effect of mine size, haulage methods, and tailings room on mill design and cite examples. They conclude with the observation that good design is defined by the way the diverse elements are composed in an operation.

Methods of Material Handling and Drying of Wet Ambrosia Lake Ores by *Richard Stoehr* and *Frank Howell.*

Materials Handling Facilities at the Ray Mines Division Expansion Program by *E. C. Speers* and *F. G. Woodruff*—This paper describes the materials handling facilities developed in connection with the expansion of the Ray Mines Div. milling facilities from 15,000 to 22,500 tpd. This expansion involved the moving and redesign of crushing facilities and a complete renovation in the ore handling systems. A change in the grinding flowsheet is also described, together with steps taken toward improving automatic control of the processes.

Material Handling Aspects of Blending for Agglomeration by *Edward P. Larsen*—This paper, with illustrations and graphs, includes descriptions of material handling systems, their performance, and the results obtained.

Innovations in Large Volume Warehousing and Handling of Bulk Materials by *W. H. Brown.*

Solid Fluid Separation

Thursday, March 2
9:00 am, Starlight Roof
Co-Chairmen: Clyde Osborn, Dale Mathews

Low-Cost Dewatering or Drying of Coarse Concentrates by *D. A. Dahlstrom* and *Robert Emmett*—Because of recent developments, particularly in beneficiation of iron ores, the need for an efficient dewatering and/or drying unit for coarse concentrates has become apparent. Since particles of 10 mesh or coarser with high specific gravities may be involved, cake formation with gravity assistance is mandatory. In addition, minimum filter cake moisture content together with high productive capacity is required, and operation usually involves abrasive solids.

In view of these conditions, the top feed filter and top feed filter dryer appeared to offer the most desirable features, while yielding low initial and operating costs. These units have been employed for many years but application has been limited, chiefly because not enough has been known about design and operation.

The paper discusses principles underlying the design of these two units, with special emphasis on feed slurry distribution methods that will insure homogeneous cake formation and construction that will resist abrasive service. Applications of both types are discussed to illustrate advantages in operation and economy.

Separation of Solids from Fluids by Electronics by *John L. Carswell*—The corona discharge which results when a potential of several thousand volts is applied to a pointed electrode may be used to supply a considerable charge to the surface of a dielectric liquid. If a grounded electrode is immersed in the liquid, an electrical field exists between the surface and the grounded electrode, and forces are applied to any particles suspended in the liquid. The settling rate of some suspensions—even some colloidal suspensions—may be greatly accelerated and the solids may be plated out on the grounded electrode. In this process conductivity of the particles is not the determining factor; forces are applied to conductive as well as nonconductive particles. The liquid, however, must be a nonconductor. There is no action with aqueous suspensions. In some clarifying processes for petroleum and vegetable oils, fuller's earth or similar material is added to the oil where it adsorbs discolorants and moisture and then is allowed to settle out. The smaller the particles of adsorbant used, the greater the surface area in contact and the higher the efficiency. However, as the particle size decreases, the settling rate increases. By using corona discharge to remove the solids, higher overall efficiency can be achieved.

Operating Control

Thursday, March 2
2:00 pm, Starlight Roof
Co-Chairmen: H. E. Uhland, J. T. Lawver

Automation in Kennecott's Western Division Concentrators by *B. T. Burwell* and *H. W. Franz*—Studies conducted at Kennecott's Western Mining Div. Research Center and at the Division's concentrators have developed practical techniques for automating various milling procedures. Comparisons have been made of the effectiveness of various measuring and control devices and studies conducted to develop the proper method of applying instrumental control to various types of treatment circuits. Much of the work has been directed toward the problems associated with automatic control of grinding-classification circuits; however, attention has also been given to control of pH of ore pulps and to such problems as control of thickener operation and automatic loading of ore bins. These studies have led to the installation of automation equipment at each of the company's concentrators; additional installations are being made or are in the planning stage. This paper reviews and summarizes this work and the findings obtained from it.

Operating Control Applications by *James P. Sheehan.*

Mass Flow Measurement of Mine Slurries by *John W. Pierce.*

Pyrolysis and Agglomeration (Joint MBD-EMD)

Thursday, March 2
2:00 pm, Zodiac Room
Co-Chairmen: Harold E. Rowen, W. F. Stowasser

Beneficiation of Cement Raw Materials by the Dwight-Lloyd Processes by *C. D. Thompson, D. C. Violetta,* and *C. A. Czako*—Mechanics of the continuous sintering process are briefly reviewed and the application of this process for the beneficiation of principal minerals used in making cement is shown. Pilot plant tests using pyrobeneficiation techniques were conducted with mixtures of limestone and shale in various ratios. Results are illustrated, showing the percentage elimination of carbon, carbonates, sulfur, alkalis and volatiles as a function of the limestone-shale ratio. Tests with varying quantities of solid fuels, added to mixtures containing limestone and shale in a 4:1 ratio, were made to attain optimum elimination of the volatile constituents. Experimental results show that 90 pct of these constituents were removed during the calcination sintering process. The advantages of using the beneficiated material for making cement are discussed with regard to preparing, handling, and firing operations.

A sintering process is described for treating raw materials or kiln waste products which contain high amounts of alkaline materials. Chloridizing roasts were performed with a high-alkaline waste dust mixed in a 1:1 ratio with raw cement meal. The data from these tests and others using different halides for aiding alkali removal are evaluated by the alkali content of the cement clinker. Test results showed that the Dwight-Lloyd process could be applied with facility in beneficiating raw materials for cement making. Substantial quantities of deleterious volatile constituents were removed by calcining and sintering techniques.

Exothermic Hardening of Copper-Nickel Concentrate Agglomerates by *M. P. Sudbury* and *F. Petkovich*—This paper describes the development of a new method of treating flotation concentrates for the preparation of feed suitable for direct charging to blast furnaces or converters. The method takes advantage of the fact that pyrrhotite contained in the concentrates can be made to undergo exothermic reactions which, under properly controlled conditions, result in formation of oxidation products that serve to cement the concentrate particles together. Thus green concentrates either in the form of pellets or briquettes containing 5 to 8 pct moisture were not only hardened, but also completely dried autogenously by continuous countercurrent shaft treatment with air. The process was developed through pilot plant operations ranging from 35 lb per hr to 2.5 tph, culminating in products evaluation tests on a railway-car scale.

New Process in Sintering Fine Iron Ores (Semi-Pellet Sintering) by *Yoshikazu Takahashi, Masao Serizawa, Kazuo Miyagawa,* and *Yasuo Shimomura*—Because they had to use finer-ground iron-bearing materials, the management of Hirohata Works of Fuji Iron & Steel Co. Ltd. was faced with decreasing sintering rates due to loss of bed permeability at a time when they were to increase steel production from 120,000 to 180,000 L.T. per month. The basic sintering burden is made up of 40 pct pyrite cinder, 40 pct fine ores, and 20 pct Mill Scale and iron sands. Serious consideration was given to research and pilot plant work in the U.S. and Sweden covering pellets and a decision was made to pelletize the fines to about 3 to 5-mm diam and mix them with other charge materials for sintering.

The pyrite cinder from flotation and suspended bed roasting was difficult to pelletize but additives such as bentonite, calcium hydrate, and sticky ores have made success possible. Bed permeability and production has increased. In 1957 drum, cone, and disc pelletizers were used in a Greenwalt pan plant with capacity of 60,000 L.T. per month. Evaluation of results governed installing 4 disc pelletizers in a new Dwight-Lloyd type of plant in 1960 where they are operating satisfactorily. A report is made covering research and development work commenced in 1954 through the intermediate tests and final application to the present operation. Graphs and charts are included.

MINING AND EXPLORATION DIVISION

Open Pit Mining

Monday, February 27
9:30 am, Chase Club
Co-Chairmen: Hugh J. Leach, Marvin E. Johnson

Use of Bucket Wheel Excavators in Difficult Ground by *W. L. Opie.*

The 'Lectra Haul' Truck and Its Use on the Mesabi by *J. L. Vint.*

The Electric Wheel Truck in Anaconda's Operations by *R. M. Stewart.*

Application of Marginal Analysis in Determining Cut-Off Grade by *Edward L. Vickers*—The operating and valuation engineer faces the ever-present problem of defining cut-off grade in gradational ore deposits. The theorist in economics has long dealt with similar problems in attempting to define the optimum rate of output in a competitive economy. This paper shows how marginal analysis—a valuable tool of the economic theorist—can be successfully applied in determining cut-off to achieve maximum total profit. Careful study reveals that many common problems in mining can be reduced to a simple statement: continue adding units of input factors until an optimum level of productivity is reached.

Surface Bench Mining Combined with Underground Haulage by *E. P. Pfleider.*

Quebec Cartier Mining Co. Iron Ore Development in Northern Quebec by *Jean Paul Drolet*—The Quebec Cartier Mining Co. development to produce iron ore concentrates is located in the North Shore area of the Province of Quebec. The ore deposits lie in the Mt. Reed-Mt. Wright area, the southwestern part of the Quebec- Labrador Trough.

Present plans call for mining large quantities of low-grade iron ore; erecting a large concentrator; developing hydro-power; building a 103-mile railroad from Port Cartier on the St. Lawrence to the mine site; and constructing a new harbor and loading facilities near Port Cartier. These installations also require establishing two modern towns, which will have a population of about 6000. All phases of the project are well under way. Target completion date for the first shipments of high-grade concentrates is the spring of 1961. QCM expects to market its products in Canada as well as in Europe and the U.S.

The film to be presented is a documentary report describing three years of construction work towards development of these large reserves of iron ore in northern Quebec.

Underground Mining

Monday, February 27
2:30 pm, Chase Club
Co-Chairmen: John J. Reed, C. David Mann

Underground Use of AN Fuel Oil Explosives by *John L. Ryon, Jr.*—The author summarizes International Salt Co.'s experience with AN fuel oil mixtures in underground blasting in the company's mines at Detroit; Retsof, N. Y.; and Avery Island, La. Initial experiments were conducted at Detroit, where several thousand drillholes were loaded with AN fuel oil mixture in the course of two and a half years. The author outlines International's experimental activities with these explosives, describes present AN loading and blasting procedures, and covers the proposed use of this material at the company's Cleveland mine, which is going into production.

Alimak Raise Climber at the Iron King Branch of Shattuck Denn Mining Corp. by *B. R. Waples, Jr.*—The new Alimak method has proved a fast, economical way of driving raises at the Iron King Branch of Shattuck Denn Mining Corp., Humboldt, Ariz. The Alimak raise climber is essentially a track-climbing drill platform, propelled by an air motor that drives pinions meshing into a guide rail rack. The climber can be lifted to any desired height along the guide rail, which is rock bolted to the raise wall. Raise rounds are quickly drilled out and the climber is swung out of the way at the bottom of the raise during blasting. All rounds are blasted electrically. Compared with the three-compartment timbered raises formerly used, the Alimak raise is 2.4 times faster in total shift time, permitting savings of $1200 in timber per raise and eliminating lost time in ventilation of raise headings.

Measurement of Rock Pressure with a Hydraulic Cell by *Louis A. Panek*—During the past three years the USBM has developed an apparatus and technique for direct measurement of existing pressure and change of pressure in mine rock. This relatively simple and inexpensive monitor is reliable for months after being installed. It is used to determine shift of ground pressure created by different sequences of mining, to ascertain the cause of rock failures, and to evaluate the need for artificial support. The technique has been employed to measure pressures in limestone, greywacke, concrete, diabase, and soft iron ore.

(Session continued on page 1248)

Theory and Practice of Rock Bolting by *Thomas A. Lang*—In addition to providing support for rock excavations, bolting creates a structurally competent diaphragm around an excavation. The author discusses the principles of rock bolting, giving typical illustrations and examples. He describes various types of bolts, acceptable methods of installation, and current techniques for grouting rock bolts to insure their permanence.

Boring Large Hole Mine Openings by *Erwin A. Morlan*—Present methods of boring large-hole mine openings are briefly reviewed. Factors that influence design and choice of down-the-hole equipment for rotary-drilling large holes are discussed. With formation drillability taken as a starting point, graphs and charts are given to aid in selection of bit load, circulation system, flow rate, drill stem, cutter design, and rotary speed.

Research Symposium

Tuesday, February 28
9:00 am, Khorassan A Room
Chairman: C. H. Burgess

Applied Research in Mining Engineering by *Evan Just* and *George Parks*.

Research in Exploration by *R. H. Carpenter*.

Underground Nuclear Testing by *Charles Bates*.

Future Trends in Mining and Exploration by *R. J. P. Lyon* and *W. H. Westphal*.

Geology (Joint with Society of Economic Geologists)

Wednesday, March 1
9:00 am, Khorassan C Room
Co-Chairmen: M. L. Jensen, J. D. Forrester

Some Aspects of Mine Geology in the Southeast Missouri Lead District by *F. G. Snyder* and *James W. Odell*—Mining geology in the Southeast Missouri district is regarded as distinct from exploration geology. The mine geologist has three objectives: 1) to assist profitable mine operation; 2) to extend the life of the mine by finding additional ore; 3) to interpret geology to operating staff and management. On the basis of his interpretation drilling programs are planned, orebodies are evaluated for development, and day-to-day problems are solved.

Under a mining geology program initiated in 1947, extensive underground workings have been mapped on a scale of 50 ft to 1 in., and a district pattern of ore controls has been established. The effectiveness of this program is revealed by production data and cost figures for the district.

The Use of Geology in Butte by *Edward P. Shea*—Since 1900, when it was organized, Anaconda's geological department at Butte has successfully employed standardized methods. Guided by the geologic record, the geologist works closely with mine operators, pursuing a policy of developing at least one ton of new ore to replace every ton mined. A formal estimate of reserves is made on the first of each year, and the geologist estimates the tonnage developed weekly to determine the current status. A geological research department with a well equipped laboratory is maintained to investigate rock alteration, and extensive studies are in progress to relate alteration to mineralization and grade in both vertical and horizontal dimensions. An exhaustive study of Butte mineralogy is under way to obtain better knowledge and understanding of the behavior of the ore minerals at the time of deposition. This information will be used to predict deep-level possibilities and locate the zones of better copper mineralization. The value of former records is demonstrated by comparatively recent projects—such as the Kelley and Elm Orlu cave mines and the Alice and Berkeley pits—which originated in the geological department.

Role of Mine Geology in Exploitation of the Iron Deposits of the Knob Lake Range, Canada by *Roger A. Blais* and *John B. Stubbins*—Operations of the Iron Ore Co. of Canada in Labrador-New Quebec have, from the start, included a large amount of geological work. During the exploration phase, from 1936 to 1950, geologists directed the mapping of more than 15,000 sq miles of desolate and remote territory. They also supervised test pitting, drilling, underground workings, volume factor and structure tests, as well as calculations of ore grades and tonnages.

In the development phase, the orebodies are outlined in detail by mapping at 100 ft to the in.; systematic test pitting and trenching with power shovels; and test and tonnage drilling. Development is carried sufficiently ahead of mining to provide reliable tonnage and grade estimates and allow final mine planning. This work costs less than 5¢ per ton of ore outlined.

All mines are mapped and plotted on plans and sections at 40 ft to the in. Geological interpretation and ore grades are revised daily on the basis of the mining data. To make full use of geology in the mining operations, the pit engineer combines the duties of geologist and mining engineer. Detailed mine geology in this district is a well recognized and relatively inexpensive necessity.

Geology at the Pitch Mine by *Arthur Baker III* and *Wm. C. Scott*—This 60-tpd high-grade uranium mine near Gunnison, Colo., offers an excellent small-scale example of the use of geology in an operating mine. Small limestone lenses, rarely containing more than 10,000 tons of ore, occur in a shear zone 300 ft wide. Both ore and surrounding rock are strongly sheared, making very bad ground that is costly to drive through and equally costly to hold open. Because of the small size of orebodies, much exploration work is necessary. Percussion long-holing is used for exploration; it has serious drawbacks but is the most effective and least expensive technique that has been found. So far the mine geologist has not been able to predict ore very far ahead of actual physical exploration; his task is careful study of all openings for the very subtle indications that there is ore nearby. On the basis of this work new orebodies have been found and known bodies have been mined as efficiently and cleanly as possible. It is probably no exaggeration to say that without the mine geologist's work the life of the mine would be halved.

Jackling Lecture Session

Wednesday, March 1
2:00 pm, Khorassan C Room

The Significance of Mineralized Breccia Pipes by *Vincent D. Perry*.

Geochemical

Thursday, March 2
9:00 am, Khorassan A Room
Chairman: Douglas R. Cook

Basic Statistical Measures in Geochemical Investigations of Colorado Plateau Uranium Deposits by *A. T. Miesch* and *L. B. Riley*—In a study of the distribution of minor elements in these deposits some basic statistical measures were computed which could be useful in geochemical exploration. Among these measures are: 1) geometric and arithmetic mean concentrations of elements in the ores and in the sandstone host rocks; 2) measures of variation of elements in the ores and host rocks; and 3) correlation coefficients between element pairs in the ores and host rocks. The geometric and the arithmetic mean are both necessary statistics in minor element studies, the appropriateness of one over the other depending on the purpose for which the mean is to be used.

The *geochemical* phi scale used in computing these measures is similar in some respects to the phi scale used in grain-size studies by sedimentary petrologists. Statistics computed on minor element concentrations, however, are reconverted to conventional units.

Quantitative Distribution of Major and Trace Components in Rock Masses by *E. H. Timothy Whitten*—Fundamental principles of trend surface analysis are briefly reviewed. Recent analyses of several granite masses illustrate the method of estimating the quantitative regional composition and also variation trends. Mineralogical, bulk chemical, and other quantitative variates can be employed. Such results should improve gravimetric surveys, which have relied until now on correction terms based on estimated rock composition. For the first time realistic estimates of the mean composition of rock bodies can be made with the aid of trend components. Present results largely involved projection of data onto a horizontal plane, but if enough data are available, use of three spatial coordinates increases accuracy for prediction in "unexposed" areas. The sampling plan is of paramount importance. Unless a suitable sampling plan is devised and adhered to rigorously, all subsequent analysis is liable to strong bias, leading to spurious estimates.

Geophysics for the Geologist and Engineer

Thursday, March 2
2:00 pm, Khorassan A Room
Chairman: Don A. Hansen

Geologic Mapping with the Aid of Magnetics, Tahawus Area, N. Y. by *Malcolm Heyburn*—Airborne and ground magnetic surveys were made over the vicinity of the Sanford Hill orebody at Tahawus, Essex County, N. Y. These geophysical surveys delineated lithologic and structural features associated with the orebodies; indicated a major extension of the Sanford Hill orebody; and guided a drilling program to prove this extension. The titaniferous magnetite orebody at Sanford Hill is associated with gabbro occurring in anorthosite. The contrast in magnetic susceptibilities of these rock types is reflected in the magnetic measurements, allowing geologic mapping that shows rock types and inferred structural features. The anomalous magnetic high of the airborne magnetometer survey indicated a southern extension of the Sanford Hill orebody. Diamond drilling, guided by results of the airborne survey and, specifically, by the ground magnetic results, substantiated the interpretation that this ore extension was of major magnitude.

Geophysical Studies in Support of Geologic Mapping in the Twin Buttes Quadrangle, Ariz. by *G. V. Keller, D. Plouff,* and *I. Zietz*—The Twin Buttes quadrangle, south of Tucson, Ariz., includes the central portion and eastern flanks of the Sierrita Mountains. Interest in the geology of these mountains has increased since the discovery of several major copper deposits in the area. Geologic mapping over the lower part of the Sierrita pediment is hampered by alluvial deposits, and the exposures are poor.

A major structural feature is the San Xavier thrust sheet—a wedge of Helmet fanglomerate and some older rocks—in the northeast corner of the quadrangle. A gravity low approximately indicates the limits of the Helmet fanglomerate, but quantitative interpretation of thickness and outline of the thrust sheet is limited by the presence of dense, older rocks along the border and in the sole of the thrust sheet. A regional gravity survey supports the hypothesis that the source of the thrust sheet may be about 6½ miles southeast of its present location.

An airborne magnetic survey was useful in mapping the extent of volcanic flow rocks under the alluvium. Flow rocks are common in the eastern half of the quadrangle and extend about six miles north of the Twin Buttes quadrangle, under cover.

Electrical resistivity soundings were made at 12 locations over the San Xavier thrust sheet to determine its thickness. The greatest depths to basement rocks were found to be 2000 to 2500 ft, in the central part of the thrust sheet, which thins gradually to the west and north, more abruptly to the south.

Use of Seismic Techniques in Analyzing Subsurface Materials by *C. R. Fahnestock*—A newly developed relatively inexpensive portable seismograph provides answers to many construction and earth-moving problems such as depth to bedrock, thickness of subsurface strata, bearing capacity, and degree of consolidation—quickly and with a high degree of accuracy.

Other techniques, principally earth resistivity, are used to obtain information on subsurface strata. Earth resistivity depends upon differential resistivity of various subsurface strata to passage of an electrical current. The refraction seismograph measures the speed of a seismic or shock wave through various layers of subsurface materials. Speed of a seismic wave varies proportionately with the consolidation of the conductor. Thus, if speed of a seismic wave through a given material can be measured, the relative consolidation of that material is obtained.

Correlation of seismic velocities with machine performance has been established for many materials. Highway, pipeline, and cable-laying contractors use seismic equipment. Bridge and tunnel builders utilize seismic techniques to obtain bearing capacities and other needed data on subsurface layers.

COUNCIL OF ECONOMICS

Interfuel Session

Monday, February 27
2:30 pm, Stockholm Room
Co-Chairmen: C. J. Potter, Charles R. Dodson

Competitive Markets: The Fossile Fuels by *Myles E. Robinson* and *W. L. Kurtz*—Since World War II the growth of natural gas in the competitive fuel market has been about four times that of oil, while both bituminous coal and anthracite have experienced declines, the decrease in anthracite being some two-and-a-half times that of bituminous coal. In electric utility generation, the only area where there are enough comprehensive data to permit comparisons of the contributions and performance of the fossil fuels, coal is playing a much more important role, showing a strong upward trend since 1949, though a break in this may have started with 1956. During the past decade the increase in thermal efficiency, among the fossil fuels, has been greatest for coal, followed by oil and gas, in this order. The national pattern, with some exceptions, has been duplicated in fuel utilization. This is of course physical and is not affected by relative changes in fuel costs. In terms of the number of BTU's required to generate 1 Kw-hr the progress of coal during the decade has been greater than that of either gas or oil, both nationally and in each coal competitive region. Finally, the cost of using coal to generate electricity, on either a physical unit or a BTU basis, has remained practically constant during the decade, in contrast to steadily rising costs in the case of both gas and oil.

Fuel Interchangeability: Measuring Its Extent in U. S. Energy Markets by *W. Gibson Jaworek* and *John J. Schanz, Jr.*—This paper presents the results of a comprehensive quantitative study of fuel interchangeability in Pennsylvania and extends these findings to national and regional survey markets.

Fuel substitution possibilities are classified as *existing, feasible,* or *impractical* according to the amount of time and money required for the consumer to change fuels. Results of various marketing research techniques, particularly questionnaire surveys, were used in estimates of the proportion of interchangeability in Pennsylvania in the four major sectors of energy utilization: 1) industrial, 2) electric generation, 3) residential and commercial, and 4) transportation. About 17 pct of all fuels consumed in the state were found to be of existing interchangeability, 49 pct of feasible interchangeability, and only 34 pct of impractical interchangeability. On the basis of results obtained in Pennsylvania, the authors present estimates of fuel substitution possibilities in U.S. energy markets. They note that interchangeable markets are concentrated in several regional areas and that these markets differ considerably among the various types of fuel consumers, and they suggest that public and private policies affecting fuel marketing take into consideration the adaptability of U.S. energy markets.

Percentage Depletion

Wednesday, March 1
9:00 am, Stockholm Room
Co-Chairmen: C. W. Merrill, Jr., J. D. Vanderwilt

Recent Federal Tax Developments Affecting Coal Mine Operators by *Richard L. Hirshberg*—This paper reviews several recent and important changes in the Internal Revenue Code which are applicable to mining and emphasizes the necessity for keeping abreast of tax developments.

In covering the following items, the author cites specific cases: 1) Definition of *gross income from mining* for depletion purposes (the problem of defining cut-off point). 2) *Economic interest* in coal contractor arrangements. Who is entitled to depletion allowance? 3) Deductibility of exploration expenditures. 4) Definition of *property for depletion and other purposes* with respect to mines. 5) Depreciation, with special reference to mining assets. U.S. Treasury proposal to change law of treatment of gain from sale of certain depreciable assets, and Treasury survey on depreciation policy.

The Depletion Rationale and Recent Political Pressures of Erosion by *Oscar H. Lentz*—The writer analyzes the causes of mounting political pressures which threaten to erode the traditional justification for depletion allowances. He sees the current controversy over percentage depletion allowances as stemming from the 1918 legislative rationale of discovery-value depletion. This was a multiple-purpose rationale, which has never been clearly understood outside the extractive industries—or within some quarters of the extractive industries.

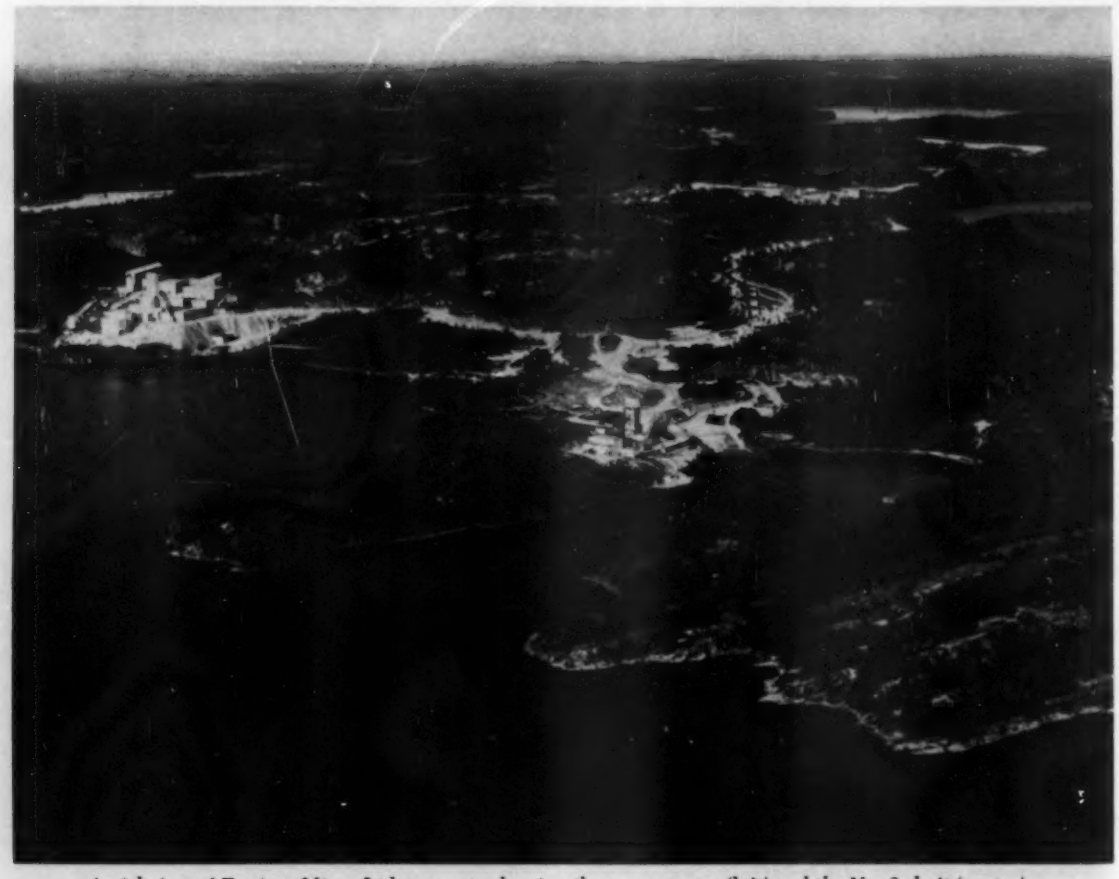
In the light of historical perspective, the author formulates the fundamental responsibility of both Congress and the leaders of industry in a free society, attributing much of the historic erosion of traditional justification for depletion allowances to the failures of industry leaders. He also lists as basic factors the growing political power of: 1) organized labor, 2) farmers, 3) government workers, and 4) old people.

Mineral Self-Sufficiency by *S. G. Lasky*—Mineral self-sufficiency, commonly taken to mean a nation's ability to supply its needs from domestic sources, is no more than a measure of performance. Except for those minerals a nation does not have, or has only in part, performance is influenced more by economic and managerial factors than by a nation's resource position. The U.S. has moved from net exporter to net importer in only 6 items in the past 40 years, and while this was happening countervailing improvements were taking place.

Some industrial dependence on imports is inevitable; an industrial nation living within its own production would end up with a technology different from that of any other nation. Nevertheless, a nation can reach a long way toward self-sufficiency if it is willing to pay the cost—but this cost will be incalculable.

Transportation of Bulky Industrial Minerals (Joint with IndMD)

(Thursday, March 2, 9:00 am. See pp. 1243-1244.)



Aerial view of Denison Mines Ltd. property showing the concentrator (left) and the No. 2 shaft (center).

DENISON MINE OPERATION AT ELLIOT LAKE

by

J. KOSTUIK

and

M. J. DE BASTIANI

Located in the Elliot Lake mining district of Canada, the Denison mine lies between Sudbury to the east and Sault Ste. Marie to the west. This area is overlain by Huronian sediments filling a basin in the Keewatin basement complex. Subsequent folding of these sediments developed a synclinal structure, known locally as the Quirke Lake Trough, which forms the northern portion of the now famous big Z structure, the geological trademark of this region. Plunging to the west and extending nine miles from the granite outcropping in the north to the Keewatin lava contact to the south, the syncline has dips of 10° to 45° on the north limb and 10° to 20° on the south limb.

J. KOSTUIK, Member of AIME, is General Manager, and M. J. DE BASTIANI, Member of AIME, is Mine Manager, Denison Mines Ltd., Elliot Lake, Canada.

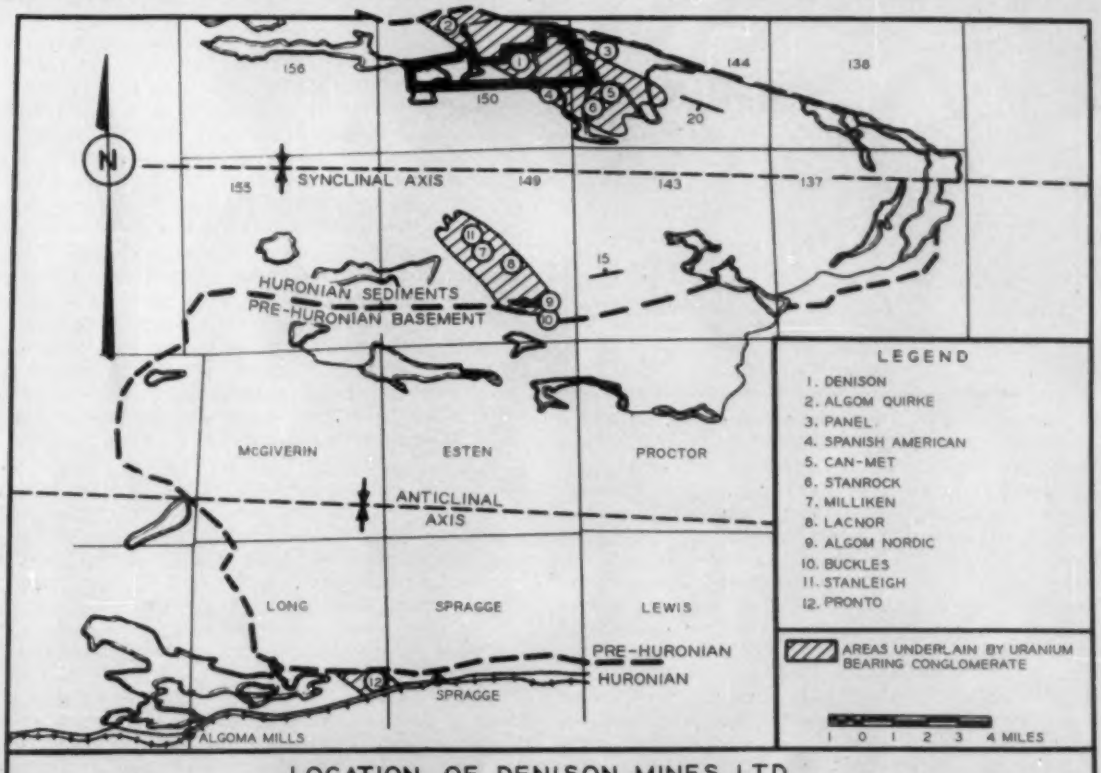
The Denison orebody, located on the north limb of the syncline, lies between 800 ft and 3000 ft below the surface. The main ore zone is within 50 ft of the Mississagi-Keewatin contact (see page 1252), and it varies in thickness from 6 ft to 32 ft. This ore zone has a composite dip of 19° to the south and is composed primarily of two pyritized conglomerate beds separated by a band of pebbly quartzite stratum. The upper conglomerate bed of the main zone varies from 2 ft to 15 ft in thickness, while the lower conglomerate varies from 2 ft to 12 ft. Over extended areas, mining is carried out over the entire section comprising the two conglomerate layers and intercalated quartzite; in other areas, the conglomerates are selectively mined, depending on the thickness of the quartzite.

The ore zone contains approximately 6 pct sulfides and 80 pct silica. The predominant uranium-bearing minerals are brannerite, uraninite, and an unidentified mineral (probably thucolite). Some of the uneconomic metallic minerals identified to date are pyrite, pyrrhotite, and chalcopyrite.

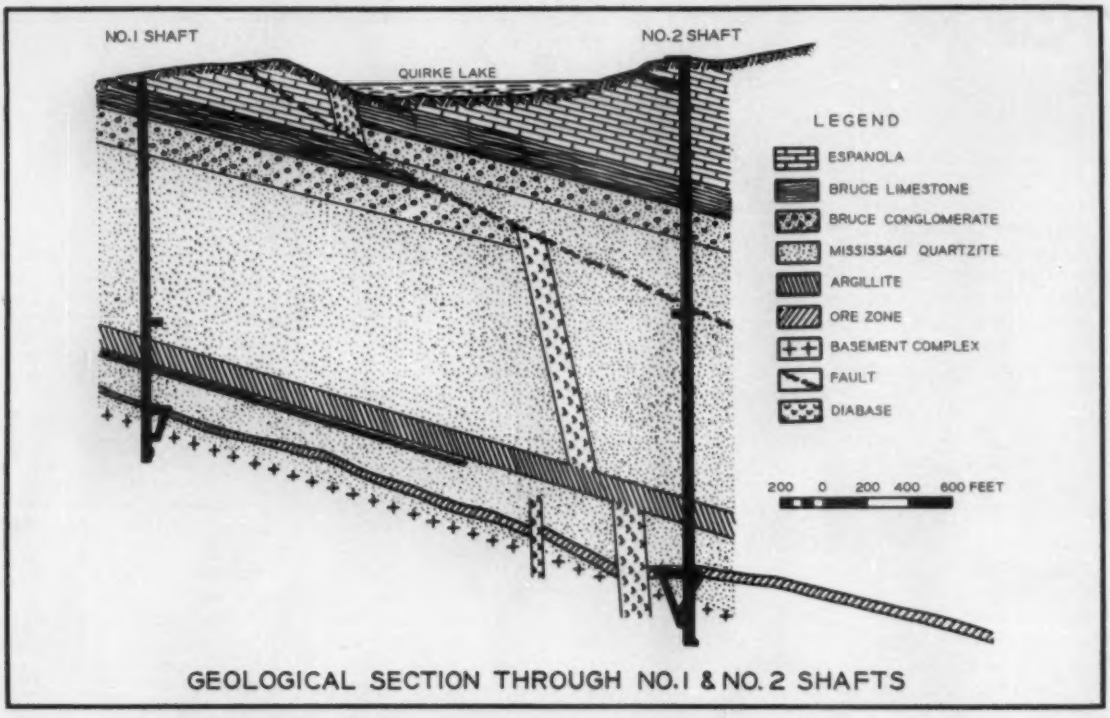
MINE LAYOUT

Shafts: Underground exploration and development were performed through two shafts one-half mile apart. The No. 1 shaft, sunk to a depth of 1856 ft with the main station established at the 1600-ft ore level, is a 250-sq ft, 5-compartment shaft capable of handling 4500 tpd. Two 5x5½-ft compartments serviced by a 12-ft diam double-drum hoist, are used for hoisting 190-cu ft bottom-dump skips in balance. A 30-man cage, offset by a counterbalance, operates within a 5½x11½-ft compartment. The fifth compartment is used as a manway, pipe and cable-way. This shaft is also provided with an intermediate pumping station used during the initial mining phase as well as loading-pocket and spill-pocket installations and pumping facilities.

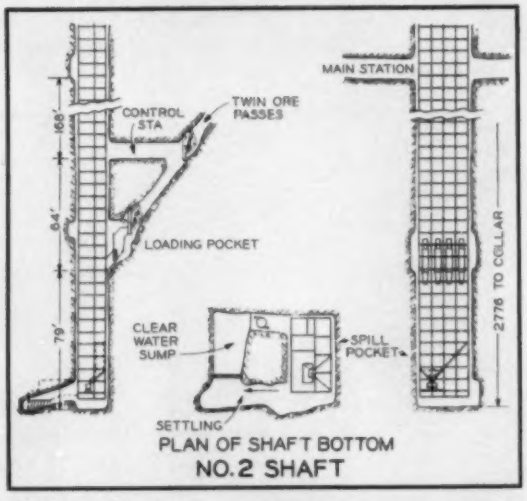
The 480-sq ft No. 2 shaft, located down-dip from No. 1 shaft, has a 2776-ft depth. Serving as the main hoisting shaft with a maximum capacity of 9000 tpd, it has eight compartments, four of which are used for hoisting ore in 10-ton capacity bottom-dump skips. These four compartments, measuring 5x6-ft in section, are serviced by two 12-ft diam double-drum semi-automatic hoists. A 50-man cage is operated in a 15x8-ft compartment, and it is counterbalanced by



LOCATION OF DENISON MINES LTD
RELATIVE TO ORE ZONES OF OTHER PROPERTIES



GEOLOGICAL SECTION THROUGH NO.1 & NO.2 SHAFTS



PLAN OF SHAFT BOTTOM
NO.2 SHAFT

a 12-ton weight. Two compartments are used for ventilation, manway, electric cables, and pipes.

A station was constructed at the 1325-ft horizon of the Nc. 2 shaft for relay pumping. The main station is located at the 2465-ft horizon, and the ore-pass control station was excavated 168 ft below the main station. The ore-pass station controls the ore from the two passes and feeds a four-chute loading-pocket. A spill-pocket is located at the bottom of the shaft in the skip hoisting compartments; it has a chute arrangement to pull the spill directly into a car on the cage. A *U*-shaped excavated area off the shaft bottom acts as a sump and is provided with settling and clear water compartments as shown in drawing (above).

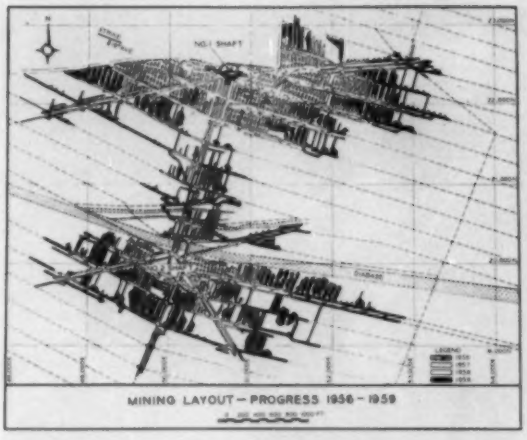
Main Air and Service Ways: A 5-entry system in the ore horizon was planned to interconnect the two shafts. The 22x10-ft openings are designed for service and ventilation, the three center entries being used as fresh airways and the two flanking openings controlling the vitiated air.

Main Conveyorways: The use of a conveyor system for hauling ore from the working areas allows the company to explore and develop within the orebody. Conveyorways are kept in the ore zone within specific limits; less than 0.5 pct of excavation is performed in waste rock. Where excessive dips are encountered over extended areas, a footwall conveyorway is cut in the waste rock. The size of the conveyorways has evolved from 25-ft widths by the height of the ore zone to the present measurements of 8x14 ft in ore and 8x12 ft in waste rock.

Trackless Haulageways: Haulageways are driven normal to the conveyorways at intervals of 250 to 280 ft. Measuring 22-ft wide by the height of the ore zone, they are used by electric shuttle cars, diesel trucks, and in some instances, by feeder conveyors. The mining layout features a system in which conveyor hauling can be adapted to all headings which have been driven as trackless haulageways, whether or not on strike.

Production Panels: The strip of ore located between two haulageways is known as a production panel. A self-contained panel consists of the haulageway (also used as an airway) and rooms of varying width driven up-dip from this haulageway. The room-and-pillar layout is designed to permit 67 pct total extraction of the panel. Twin headings are driven only when development is spearheaded for a special purpose and the strike advance makes normal pilot breakthroughs impossible.

A total of 12 to 15 panels in different phases of development and mining sequence is required to maintain production at existing capacity. In addition, an advance of 1000 ft per month in an average height of 12 ft of ore is required to maintain the developed reserves. Each foot of panel advance de-



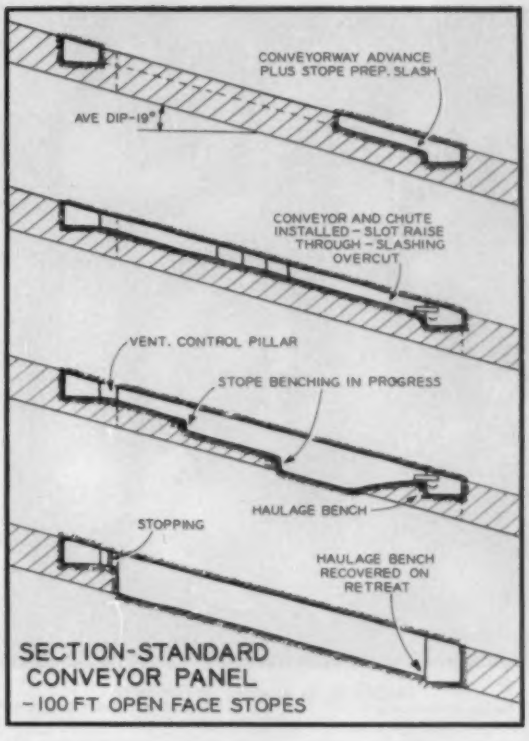
MINING LAYOUT – PROGRESS 1956 – 1959

velops 90 to 450 tons of ore, depending on the thickness of the ore zone. Strike haulages in the thinner ore areas are driven at a much greater pace to keep the ratio of up-dip ore in balance.

MINING METHODS

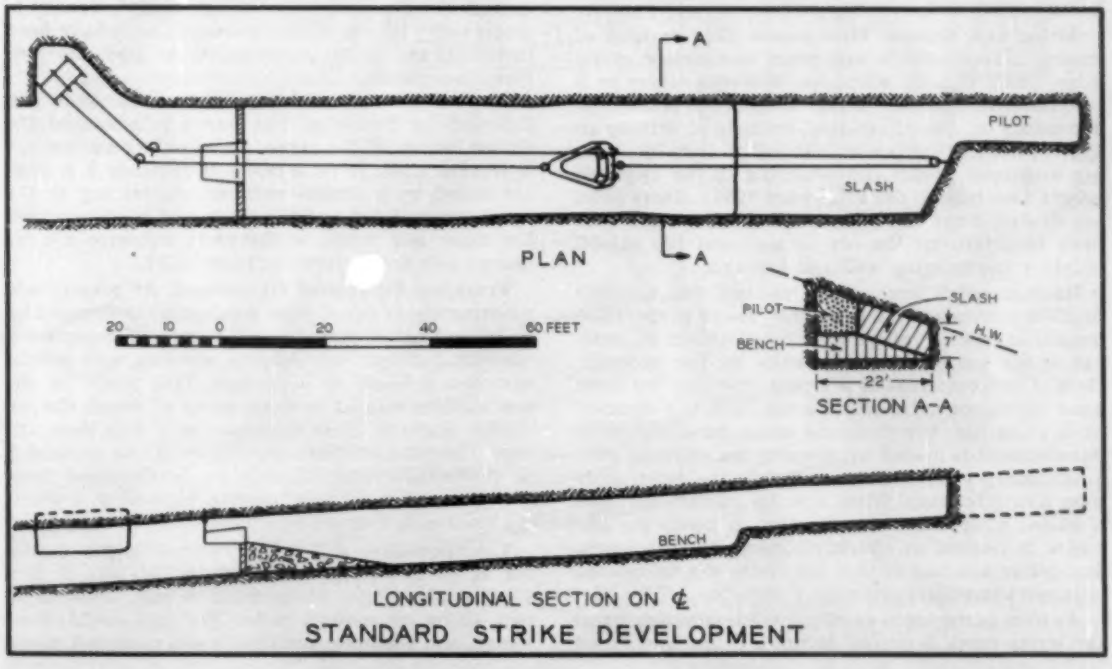
Approximately 83 pct of the ore is produced by airleg, slusher hoist, and scraper mining while the remainder is derived from drillmobile-scoopmobile operations. Though the ore may be broken and loaded by two different methods, the hauling from these operations is accomplished by either electric shuttle cars, diesel trucks, conveyors or by a combination of rubber-tired vehicles and conveyors.

The basic plan of development in the orebody is to drive the main artery, usually a conveyorway, and to erect the conveyor as soon as one panel length has been reached, overpass facilities have been provided, and haulageways and conveyorway faces have advanced 30 ft beyond the loading points of the conveyor. Following the extension of the conveyorway, a loading chute is provided for the haulage


CONVEYORWAY ADVANCE PLUS STOPE PREP. SLASH
AVE DIP-19°
CONVEYOR AND CHUTE INSTALLED – SLOT RAISE THROUGH – SLASHING OVERCUT
VENT. CONTROL PILLAR
STOPE BENCHING IN PROGRESS
HAULAGE BENCH
STOPPING
HAULAGE BENCH RECOVERED ON RETREAT

SECTION-STANDARD CONVEYOR PANEL – 100 FT OPEN FACE STOPES

road and a scraper chute is installed at the end of the belt to permit direct loading of the broken ore from the advancing artery. Haulage roads on either side of the conveyor are then advanced approximately 200 ft by scraping broken ore directly onto the belt. By the time the limit of economic scraping has been reached, the access is available either to allow the use of trackless haulage equipment or to install feeder conveyor belts.



STANDARD STRIKE DEVELOPMENT

Mobile ramp slushing at Denison.

Dumping uranium ore on the grizzly.

The mining operation features hanging wall control on either the upper or the lower reef of the conglomerate section. When the thickness of the intercalated quartzite is such that it does not unduly lower the grade, the reefs are mined together. Hanging wall control is of major importance in respect to safety and dilution because 1 sq ft of roof is exposed with every ton of ore mined. With today's trend being definitely toward selective extraction, careful training and supervision of crews installing roof supports are producing favorable results in relation to back and dilution control.

Airleg and Scraper Operations: This method of mining is applicable to any phase and section of the mine, being equally adaptable to strike drives as it is to room-and-pillar mining. The normal procedure, depending on size of heading, consists of driving an 8x8-ft pilot drift which is followed in turn by slashing to proper width and benching to the required height (see bottom drawing, page 1253). Short holes are drilled from the pilot heading on room center lines to determine the ore section and the cut-off points in the hanging wall and footwall.

Haulage roads are usually slashed and benched to 22-ft widths and 12-ft heights. Room preparation usually is concurrent with the development of haulage roads parallel to the strike of the orebody. Both of these operations are performed by the same crew which normally overcuts the room to a distance of 40 ft up-dip. Ore from the strike drive and room development is loaded by scraping the material over a stationary steel chute installed in the heading or over a mobile ramp. When a 50 hp slusher hoist and a 60-in. scraper hoe combination is used, the advance is limited to 150-ft or increments of room-and-pillar interval so that the chute can be located adjacent to a pillar.

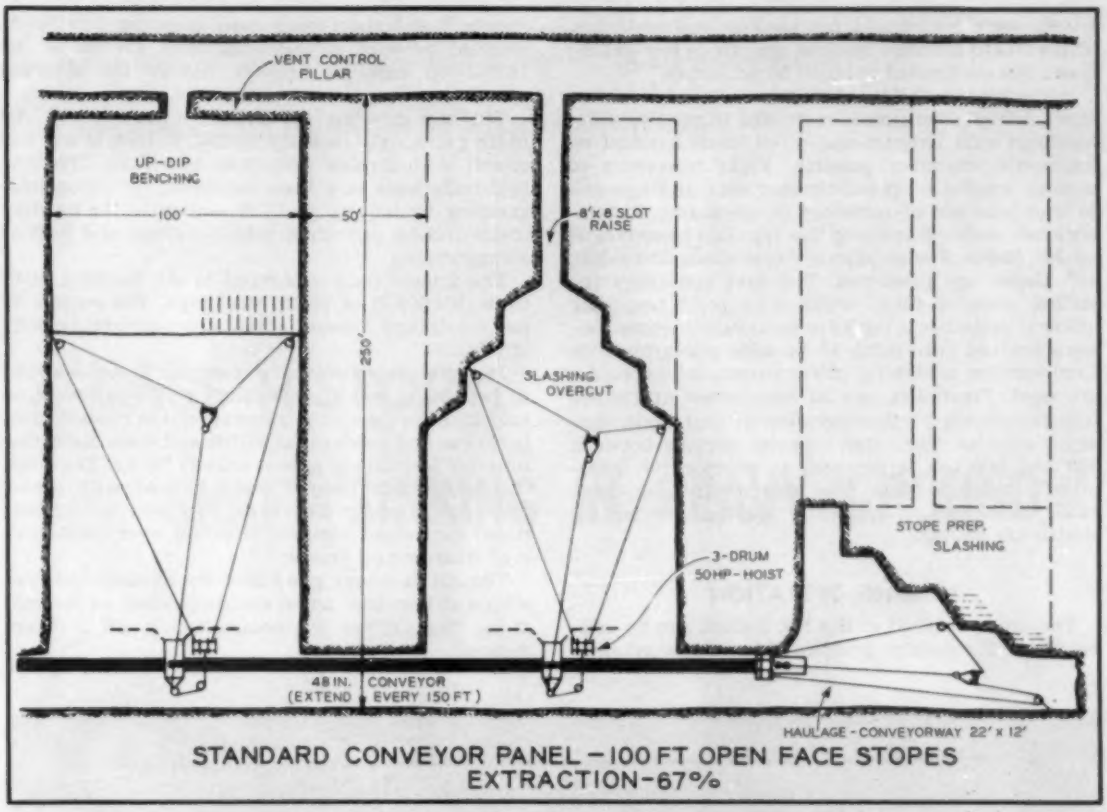
As soon as the room development is completed and the strike ramp is moved ahead, a chute is installed in the center of the room with an electric hoist located to one side. The type of chute employed is designed for rapid erection and rugged service. The construction and erection costs approximate 4¢ per ton, and all original chutes are still in operation today. The chute is attached to a rock sill at the front and suspended at the discharge end with chains and safety cables. A minimum height of 11 ft on the up-dip side of the heading is required to erect the chute for shuttle car and truck loading.

The standard roadway width of 22 ft allows enough clearance for two haulage units, essential in single entry panels. Where conveyor belts have been installed, the chute is arranged to load the belt through a grizzly.

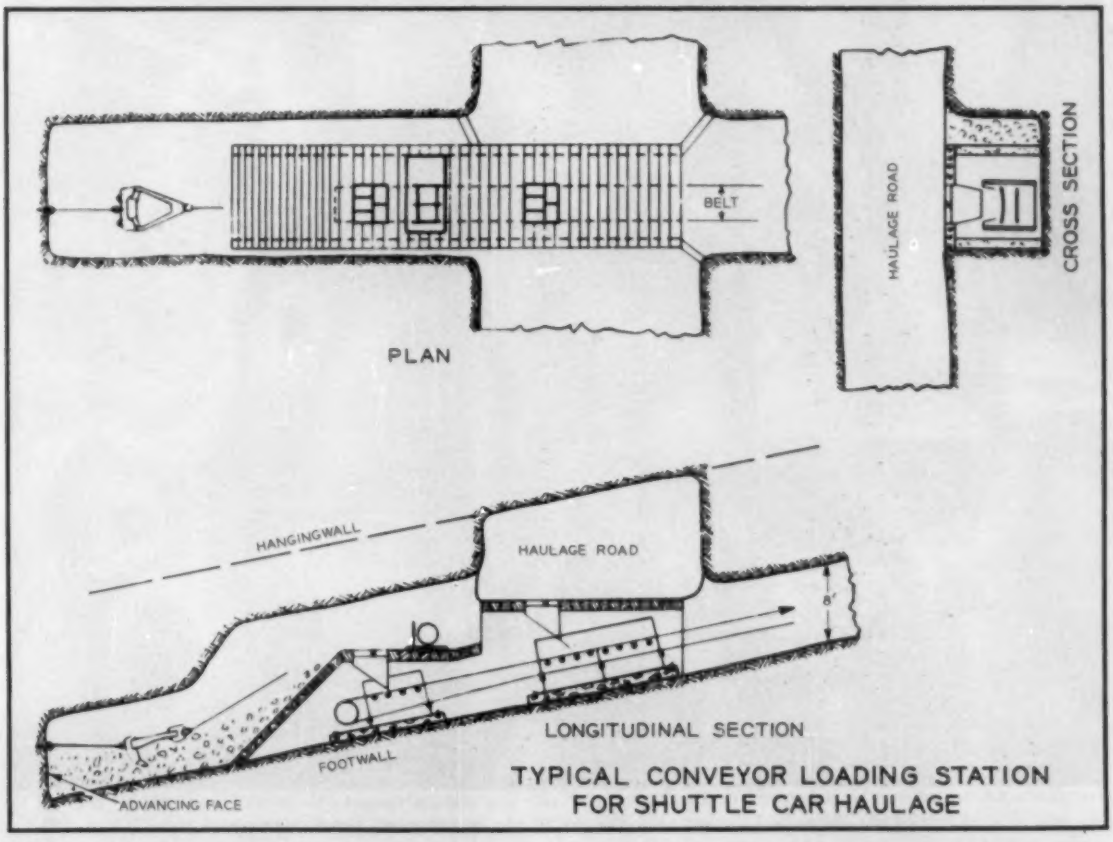
Ore thicknesses exceeding 8 ft are top-sliced and followed by benching. The bench is advanced the entire length of the room. In areas where the ore is thicker than 16 ft, a series of benches 8 ft high are taken in a similar manner. As mining in the room is completed and the chute and hoist removed, the pillar and bench at the room entrance are removed (see upper drawing, page 1255).

Trackless Equipment Operations: At present approximately 17 pct of mine production is obtained by room-and-pillar mining using mobile equipment, consisting of front-end loaders, working with tractor mounted 3-boom drill-jumbos. This phase of the operation is limited to those areas in which the ore section exceeds 10-ft thickness with less than 10° dips. The most efficient application of this method is in down-dip rooms adjacent to development faces where both can be conveniently worked on a rotating basis with common equipment.

Transportation of Ore: The 14-ton capacity shuttle car is designed for grades up to 34 pct. It is a 4-wheel steer, four-wheel drive vehicle powered by two 40-hp dc motors. After the two shafts were joined, and adequate ventilation was provided, diesel



STANDARD CONVEYOR PANEL – 100 FT OPEN FACE STOPES
EXTRACTION-67%



TYPICAL CONVEYOR LOADING STATION
FOR SHUTTLE CAR HAULAGE

trucks were introduced for hauling and servicing. These trucks are very flexible, operate in low-ceiling areas, but are limited to about 30 pct slopes.

Although the ability of shuttle cars and trucks to climb is high, their use is restricted to relatively flat headings with long up-and-down hauls handled by conveyors wherever possible. Eight conveyors of various lengths are presently operating underground to transport run-of-mine ore to the passes. Experience has shown that ore of this type can be conveyed up 20° slopes. For satisfactory operations down-hill, 10° slopes are preferred. The first conveyors installed were of 42-in. width with solid troughing idlers mounted on a rigid frame understructure. Designs evolved until today 48-in. wide conveyors with Limberroller troughing idlers suspended on cables are used. Flexibility can be maintained at 180,000 tons per month by the operation of four main conveyor arteries. The rated capacity varying between 300 and 800 tph is required to provide for intermittent surge loading. The bottom drawing, page 1255, illustrates a conveyor loading station for shuttle car haulage.

MILLING OPERATION

The ore is crushed at the No. 2 shaft site by conventional three-stage practice using a jaw crusher, standard and short-head cone crushers. The ⅝-in. crushed product is then conveyed 600 ft to the 16,000-ton capacity fine-ore bin at the grinding plant.

The wet grinding is carried by open circuit rod milling and, until recently, by ball milling in a closed circuit with duplex rake-type classifiers. The four ball mills have now been converted for autogenous grinding by bolting an 11-ft section to the existing shells and by providing pebble-making and feeding arrangements.

The ground pulp is pumped to the leaching plant through 3000 ft of 10-in. steel pipe. The pulp is 35 pct solids and travels at an approximate velocity of 5 fps.

In the leaching plant the slurry is first dewatered in two stages to 17 pct moisture and repulped in an acid solution. Leaching is carried out in rubber-lined pachucas and mechanical airlift agitators. Retention time for leaching is approximately 50 hr. The solution-solids separation is accomplished with center pier-type washing thickeners followed by conventional two-stage vacuum filtration over cloth-covered wire-wound drums.

The ion exchange plant is of the moving-bed type with a strong-base anion exchange resin as the medium. The tailings are neutralized to pH 9 before disposal.

View of the chute and slusher arrangement in one of Denison's production panel areas.

The modification of a three-compartment rectangular shaft to a four-compartment elliptical shaft solved a serious problem of rock pressure which threatened to terminate a shaft sinking project in Cuba. Although the work was completed in 1955, this method has present-day applications.

A CASE HISTORY:

SHAFT SINKING IN HEAVY GROUND

by RICHARD P. GERWELS

Minas de Matahambre, a copper mine located 100 miles southwest of Havana, Cuba, has produced 10 million tons of copper ore since it was first opened up in 1913. During the mid-1950's the mine was producing approximately 1000 tpd and had attained a depth of 3600 ft.

As shown in Fig. 1, the property contains three shafts: the No. 1 shaft, 2100 ft deep and located 2000 ft south of the No. 2 shaft, provided service to the 2100 level; the vertical 3600-ft No. 2 shaft handled all production to the 3400 level; the No. 3 shaft on the northeasterly fringe of the mining area was in a semi-active status.

The last-mentioned shaft, lying 1250 ft northeast of the No. 2 shaft, had been sunk 1300 ft from the surface to the 1800 level during various periods from 1929 to 1948. Its importance to the mining operation at this site became paramount when it was decided to deepen the No. 3 shaft by an additional 2000 ft from the 1800 to the 3400 level. The primary objective of this project was to allow more extensive exploration work, as well as providing a service shaft and secondary exit from below the 2100 level, production in an emergency, and improved ventilation, particularly on the lower levels. With these objectives realized, the overburdened No. 2 shaft would be relieved and afforded more time for production and repairs.

During the first eight months of the shaft-sinking operations, the project was a routine matter with total progress attaining 1119 ft of added depth. At this point, however, heavy ground was encountered which slowed progress to such an extent that the shaft was sunk only an additional 376 ft during the next ten months at a cost of approximately $1000 per ft. After sinking a total of 1400 ft of the proposed 2000 ft, the cost of the project, excluding the purchase of a new double-drum hoist and certain surface facilities, had reached $675,000. The alternative of an offset shaft from the 2600 level to the 3400 level was considered, but this presented attendant operational problems and added expense. At this stage of development, abandonment of the project was seriously considered.

In an effort to avoid the closing down of the shaft-sinking project, the author began a detailed study of the geology as exposed in the No. 3 shaft and in other sections of the mine. This work developed positive evidence as to the main cause of the extreme ground pressure being encountered and led to a change in the design which would allow the shaft to withstand the extreme pressures being applied to it from the country rock.

GEOLOGY

The Matahambre mine is located on the northwest flank of a regional anticline. The country rock, consisting of shales and sandstones, is known as the Cayetano formation of Cretaceous (?) age. The prevailing strike of the beds is N50°E, with dips of 40° to 60° northwest. Local warping with accompanying strike and dip variations is common. No igneous rocks are known within a radius of several miles of the mine. Alteration in the proximity of the orebodies is slight to moderate.

Dynamic metamorphism, due to regional folding, has not been extreme. However, induration of the shales resulted and the more pure sandstone became quartzite. Part of the stresses, presumably developed by folding and later faulting, appear to be still operative in the rocks.

Faulting is common. The dominating structure is the Manacas fault zone. Between No. 2 and No. 3

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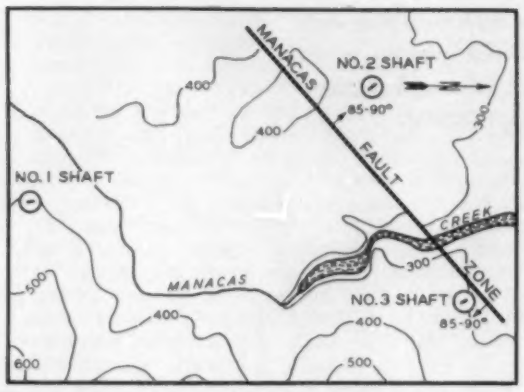


Fig. 1

shafts it has a clockwise rotating strike from N50°E at the surface to N60°E on the 3400 level. This fact is accounted for by the near-vertical northwest and southeast dips at the respective shafts. The Manacas fault was a major factor in subsequent planning and seeking a solution to the No. 3 shaft problem.

Immediately southeast of the No. 2 shaft the Manacas fault has been exposed in successive levels through a vertical distance of 3600 ft. Here it has a northwest dip of 85° to 90°. Near No. 3 shaft the Manacas zone was partially exposed during excavation for the new hoist building. Its dip from the surface to the 1800 level, where the No. 3 shaft sinking started, is believed to be essentially vertical. A drift connection made from No. 2 to No. 3 shafts on the 2600 level crossed the Manacas fault 50 ft northwest of No. 3 shaft. Thus a southeast dip of 86° was established from the 1800 to the 2600 level. As a result, further sinking from the 2600 to the 3400 level pointed to crossing or intersecting the fault. In the meantime, a drift was driven from No. 2 to No. 3 shaft on the 3400 level. This drift indicated that the northwest end of No. 3 shaft would be sunk in the southeast fringe of the Manacas fault. During sinking, the fault zone was revealed on the northwest end of the shaft at about the 3000 level from where it remained practically vertical in the shaft to the 3400 level.

Subsidiary gouges and shears, either parallel to the Manacas fault zone or intersecting it at acute angles from an easterly direction, also contributed to the difficulty in sinking operations.

THE SINKING PROBLEM

Deepening No. 3 shaft represented a continuation of a standard three-compartment shaft (Fig. 2, top). Its dimensions outside the 8 x 8-in. timber are 6 1/3 x 16 2/3 ft. All three compartments (before modification) measure 5 x 4 2/3 ft in section, and the vertical spacing of sets is 5 ft center-to-center. The first 1119 ft of shaft sinking was uneventful. However, during the next three months sinking in heavy ground was a continual source of difficulty and concreting became a necessity. The following 60 days saw the shaft extended only another 126 ft for a total of 1335 ft, thus placing it 135 ft below the 2600 level after 13 months of sinking operations.

At this depth, the persistent ground pressure created a hazard. The guides became warped and the wall plates were squeezed to the point that made clearance for the sinking cage a day-to-day chopping operation. Rock bolts were substituted for concrete to help stabilize the walls, but some bolts became buried in the end plates. Finally the timber was removed, and the shaft was enlarged and again concreted. The concrete was usually poured to allow a wall thickness of 18 to 30 in., and one or two curtains of ¾-in. diam reinforcing steel were generally used. At places this reinforcement was augmented with 20-lb rails. In order to hasten setting before any wall movement could occur that might damage the concrete, 2 pct calcium chloride was added to the mix water. Previous concreting at the 2600 level station utilized 12-in. 42.9-lb steel *I*-beams for bearer sets. The actual horizontal span between the concrete-encased ends was 6 1/3 ft. In a matter of weeks enough ground pressure developed to cause the *I*-beam webs to buckle, necessitating their replacement.

In the following two months only 75 additional ft of shaft was sunk and concreted. Slow as it was then, the entire operation came to a halt when about 25 ft of the shaft caved on one side and carried all timber and the Riddell mucker to the bottom. Fortunately this event occurred during the lunch hour when the men were out of the shaft. About 30 days were spent repairing and concreting the caved section.

THE SOLUTION

About six weeks prior to the cave-in, the writer started detailing the shaft geology. A drift being driven on the 3400 level of the No. 2 shaft to connect with the No. 3 shaft was located adjacent to the Manacas fault zone. The drift revealed that considerable pressure developed in the incompetent shales when the direction of the drift approached the strike of the beds. In fact, several hundred ft of the drift were abandoned because of the necessity of retimbering to keep the drift open. Except in faulted sections, the No. 3 shaft was fortunate in that the beds encountered had a strike almost normal to the long dimension of the shaft. However, this feature changed radically from a short distance above the 2600 level, through the faulted sections, to the 3400 level.

Much of the shaft trouble caused by heavy ground resulted from faults of lesser magnitude that were associated with the Manacas fault zone. Contributing factors were apparently unrelieved rock stresses caused by folding and faulting plus the lateral pressure of a superincumbent load of 2700 to 3400 psi.

After thorough study, it was recommended that the shaft's cross section be changed to a semi-elliptical shape (Fig. 2). The new design required the manway to be transferred to the opposite side of the shaft; the two hoisting compartments remained unchanged; the pipe compartment was left on the other concave end. The modified design of the shaft made it more capable of withstanding side and end pressures. In the redesigned shaft, the maximum moment would be lessened considerably, and the convex ends would be in compression. In addition, the modification would permit a direct labor and materials savings approximating 20 pct, as well as saving the project and avoiding the possibility of sinking of an offset shaft with attendant operational problems and expense. The disadvantages, minor in nature, consisted of 1) the necessity of modifying existing shaft sets, 2) a 20 pct decrease in ventilation area, and 3) a decrease in the size of the manway pipe compartments. The transfer of the manway required the men using it to cross the hoisting compartments until additional work eliminated this hazard.

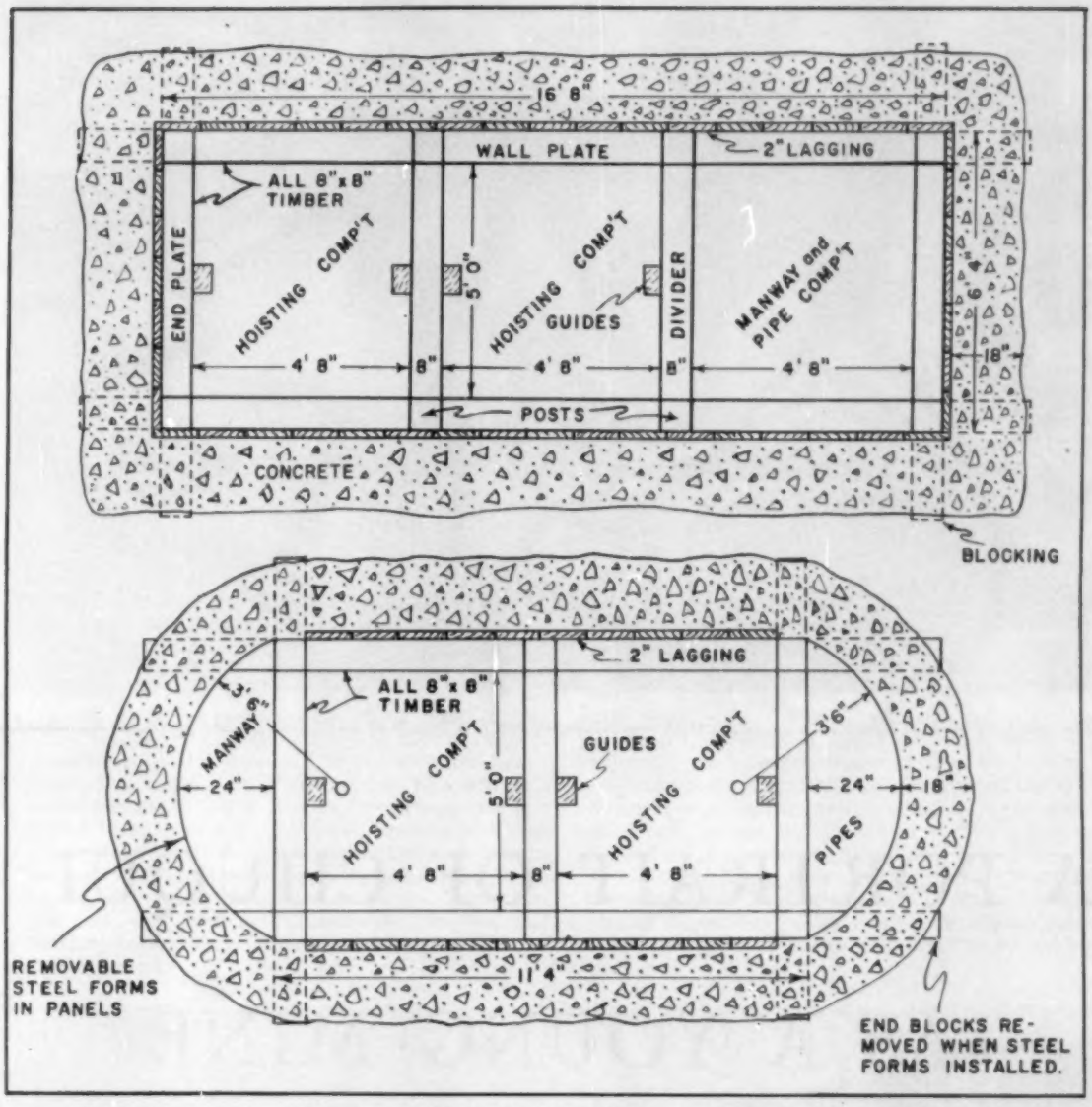
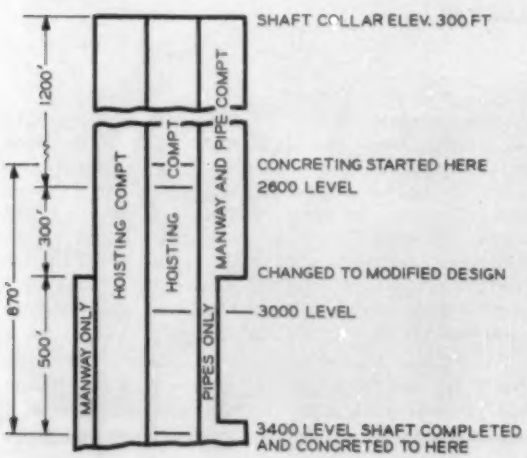


Fig. 2—Cross-section of the original shaft (top) and modified version (bottom). Side view (below, left).



Removable steel forms for the convex ends were designed in two panels, each weighing 150 lb. During concreting operations, the panels were installed with tapered steel pins and braced against the end plates and posts. Reinforcing steel continued to be required but its use was drastically reduced, particularly on the convex shaft ends.

Change to the modified shaft took place 294 ft below the 2600 level. Sinking and concreting of the remaining 500 ft of shaft was completed in less than six months at an average cost of $497 per ft, including cutting of stations on the 3000 and 3400 levels.

In conclusion it may be noted that the successful completion of this shaft engineering project extended to a study and analysis of the nature and geometry of the formations and structures causing the heavy ground—in a word, the geology which threatened to terminate all sinking.

The pangs of birth of a famous mine begin with the cutting of the first bench in 1914, but greater problems lay ahead.

A PORTRAIT OF CHUQUI AS A YOUNG MINE

by THORP D. SAWYER

In June 1914, one week before I was to be awarded my sheepskin in upper New York State, I received a telegram from New York City which read "Can offer you position as engineer in Chile at $115 a month contract for one year. (*signed*) Chile Copper Co." That night, Friday, I took a sleeper to New York and arrived at the Guggenheim Brothers' company office at 165 Broadway, just as it was opening up on Saturday morning. Saturday was no holiday in that era.

Presenting the telegram at the office, I was ushered into a sub-executive's office and shown a mimeographed contract which 1) agreed to pay me $115 per month from the date of leaving New York until I returned, and with travelling expenses both ways, 2) fixed a charge of $46 per month for board and lodging in company quarters, and 3) stipulated a contract term of one year with the right to retain my services for another year if the company so elected. While a bit huffed at the year's "kicker" I nevertheless accepted. I was then told to prepare to leave the following Wednesday (June 17) on a United Fruit Co. steamer for Panama. Objecting that I still had to receive my degree on the 17th and had planned a vacation in Ohio for a week or so, I was curtly told that I would have to leave on Satur-

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day's boat, June 20, or not at all! That was that. I left on schedule.

In those days the trip from New York to Antofagasta, Chile, took about a month: six days to Colon with a delay of three or four days to board a steamer bound for Valparaiso, and a two-week trip to Antofagasta, which included numerous stops along the Peruvian and Chilean coasts. From Antofagasta, Chuquicamata lies approximately 150 miles northeast and was reached by the Antofagasta & Bolivia Railway. The "A & B" was then an efficient railway which ran semi-weekly trains 800 miles to La Paz, Bolivia.

In the company of several other contract employees, I arrived at Chuqui on the morning of July 17. I was assigned to the construction department and told to report to the field engineer's office immediately after depositing my belongings in a room at the staff quarters for single personnel. These quarters consisted of four corrugated-iron buildings containing 14 rooms apiece. Each room was to be shared with another employee. Oil lamps provided lighting in the buildings and also served to heat the rooms at night.

MINE DEVELOPMENT

By the time of my arrival, the main bench from which the mining operation would start was in the process of development. Designated "Bench C" it had 100 ft banks and a 2.6 pct grade to facilitate tramming of loads to the assembly yard where the ore cars would be made up into trains. Bench *C* was to be blasted by a series of blasting tunnels located parallel to the cut face and 10 ft below the bench level. The tunnels were spaced 100 ft apart with cross cuts every 750 ft. The earlier prospecting and initial blasting of this and lower benches had been accomplished with Keystone steam churn drills, the necessary coal and water supplies being transported to the drill site by mule carts or burros. Loading of the rock was done by railroad-type Bucyrus and Marion steam shovels purchased from the Panama Canal project.

As originally planned by the Guggenheim Brothers' consulting engineer, Pope Yeatman, steam shovels were to mine the oxide zone of the deposit to a depth of several hundred ft. The benches were to be 100 ft or more in height, and blasting was to be done with tunnels as previously explained. The middle bench, *C*, was the first to be opened up, and *B* and *D* were to be developed once *C* had receded sufficiently to make such work feasible. At the same time, the driving of blasting tunnels was begun from shafts well outside of the oxide zone.

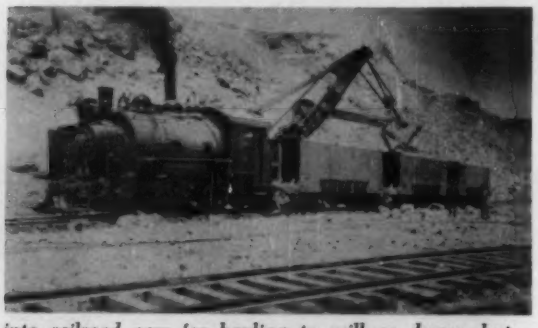
In the practice which grew out of the experience of the first few years of operation, it became customary to load a 1000 to 1500-ft long face with pockets of black powder located every 30 ft. Several boxes of 60 pct dynamite attached to two 220-v circuits served as primers. As each pocket was loaded, the intervening areas between pockets were stemmed with waste. When completed, the cross cuts were stemmed back to the next row of tunnels.

In 1919, one shot contained 306 tons of powder and broke approximately 750,000 tons of rock. This feature, and the economies which had been assumed to result from it, was probably the main reason for adopting the "high bank" mining system. Before World War I when copper was selling for 12¢ per lb, Yeatman had estimated that this mining method, coupled with the new leaching and electrolytic precipitation process developed by E. A. Capellan Smith, would permit copper to be produced for 5¢ per lb. This figure was approximated during the mid-1920's when the dollar was still worth a dollar.

Located at the lower end of the bench was a large assembly yard for classifying ore and waste cars in making up the trains. Within the area of the mine, 60-ton Porter saddle tank locomotives were used to haul both empty and loaded cars. The waste was hauled in 12 and 20-cu yd Western side-dump cars to either the dump sites or to the various plant construction projects for use as fill. When the plant started operating, the ore was hauled approximately four miles from the mine to the mill in 60-ton hopper cars.

Occasionally, blasting operations in the early days were hard on machines. Huts (left) shield men from flying debris.

At the mine, railroad-type shovels loaded rock—



into railroad cars for hauling to mill or dump, but—

side effects of blasting took their toll on production.

PLANT DESIGN

By July 1914, the plant was about 50 pct completed and scheduled to be in operation by May, 1915. It was to handle 10,000 tpd of ore initially, with an increase to 15,000 tpd after completion of slight additions provided in the plant design.

In the initial plans, the ore was to be delivered over a ¼-mile steel railroad trestle to the top of the bins and discharged through the hopper bottom cars onto 12-in. spaced grizzlies. The ore would then be fed onto two longitudinal conveyor belts discharging into two No. 10 McCully gyratory crushers. From there it would be elevated by belts to four 48-in. horizontal Symons discs and thence by gravity to eight 54 x 20-in. Garfield rolls. The crushed product, approximately ⅜ in., would be conveyed to a sampling tower and along the upper edge of six 150 x 110 x 18-ft reinforced concrete mastic-lined leaching vats to a loading bridge spanning the tanks. Each vat had a 10,000-ton capacity and was to be loaded by a traveling tripper on the bridge. Near the vats were a series of solution sumps of similar construction with a network of lead-lined steel pipes. The pipes would transfer the various acid leaching solutions required in the beneficiation process and deliver the acids to the dechloridizing plant.

The dechloridizing plant consisted of several large trunnion-mounted, rubber-lined steel tanks filled with copper shot for agitating the strong solutions and depositing out the chlorine as cuprous chloride. The strong dechloridized solution would then be pumped to a head tank for dilution to the proper gpl-content for electrolytic precipitation in the tank house. From the tank house, the cathode copper was to be trammed to the smelting and refining plant located about ¼ mile to the west.

The leached tailings were to be unloaded from the leaching vats by a clamshell bucket travelling on a runway from an unloading bridge spanning the vats with clearance for the loading bridge to pass underneath. From a hopper, the tailings would be discharged onto a conveyor belt system and elevated to the dump.

A temporary acid plant, constructed of wood, was erected on a hill some distance from the main plant site. It was thought that once the required acid had been produced, the ore would continue to generate sufficient quantities of acid to keep the operation going without further assistance from the acid plant. After operations began, this building was dismantled before it was realized that acid was not being adequately generated.

Power for the mine and mill operations was supplied during the construction period by a large Corliss engine plant pending the completion of a 40,000 kw German-built steam plant at the seaport town of Tocopilla and the 100-mile 110,000-v transmission line to the plant. During the construction, water was purchased from the Antofagasta & Bolivia Railway and pumped from its nearest station, located ten miles away and at 3000 ft lower elevation. In late 1914, a 60-mile long 12-in. pipeline was under construction from the San Pedro River, and another 60-mile pipeline was under consideration from Toconce Springs. The first line was for process water and the latter line was to be used for potable water.

COMMENCEMENT OF OPERATIONS

From July 1914 to May 1915, when operations began, the pressure on the work force was terrific. World War I had begun in August 1914 and threatened to cut off supplies. For weeks at a time, rumors persisted that a shut-down was imminent. Field men worked ten hours a day, six days a week, plus seven hours on Sunday. On the latter day the field staff got off at 3 PM to take a bath—if an unoccupied tub could be found. The office force worked nine hours daily and a half-day on Sunday. After full-scale operations began, both field and office forces got off an hour earlier and had Sundays free. The mine and mill, however, were operated on 8-hour shifts, seven days a week.

Once the operations started, the bugs in the process began to appear. The tunnel blasting (coyotes) broke the ore into such large blocks that shovel loading was drastically slowed down due to the necessity of frequent secondary blasting by mud-capping or block-holing. When such blasting became necessary, most of the bench operators had to seek shelter in huts made of railroad ties. Even with this additional fragmenting, the ore was often of such size that it would stick in the hopper bottom cars unloading into the bins. Once unloaded, much of the ore was still too large to pass the 12-in. grizzlies. During the first year of operations, this problem resulted in the employment of a 20 to 30-

man work force stationed at the ore bins around-the-clock to break the ore so it would pass the grizzlies. This situation cut ore production to 50 pct or less of capacity.

By late 1915, it was decided to construct a primary crushing plant to reduce the run-of-mine ore to less than grizzly size. The design provided for two 84 x 60-in. Blake jaw crushers (weighing 425 tons each) fed by a jaw-type movable car dumper located close to the ore bins. However, as it was designed, only one crusher at a time could operate because the rail-mounted car dumper had to travel from one crusher to the other. This plant was completed early in 1917 and did away with the unloading cars over the bins. It helped to step up production but, in the meantime, other troubles began to emerge both at the mine and at the plant.

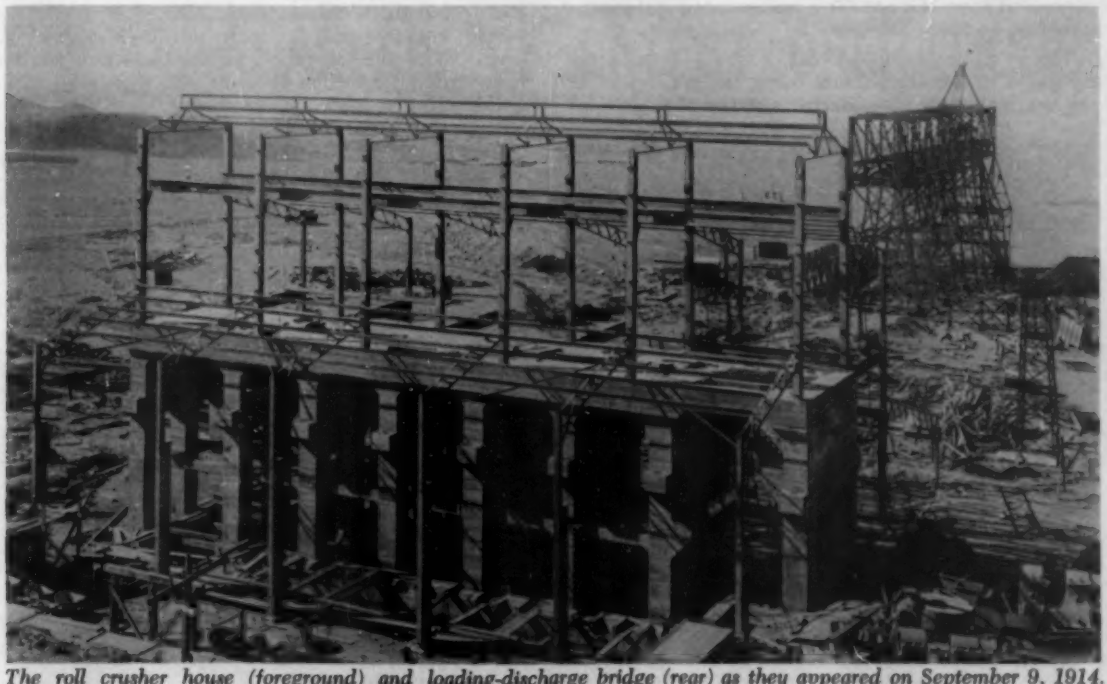
Blasting operations at the mine soon included toe-drilling, mud-capping, and blockholing in addition to the tunnel blasting. The percentage of fines from these operations became so high at times that the crushing plant, not having modern dust collecting systems, became an impenetrable fog of dust. Wetting of the fines by fire hoses during dumping operations helped, but such action would often cause packing of the material causing a further delay. Once, this packing split the cast steel frame of one of the Blake crushers.

In addition, the science of blasting with tunnels was still in its infancy and forecasts of how far a given blast would throw its load were frequently in error. The net result would be shovels overturned, loading tracks blasted off the bench, and other equipment damaged. Further, many of the early churn drill blast holes had misfired and were often responsible for accidents when the shovels dug into them. By 1918, however, enough was known of the behaviour of this rock in blasting to enable the engineering department to predict, within an accuracy of a few feet, where the toe of the blasted face would reach.

The early churn drills at work on top of a bench.

In time, it became obvious that high banks were not only dangerous but made it virtually impossible to maintain an even grade of ore to the mill to permit the crushers, leaching, tank house and smelter to work at optimum capacity. In the effort to keep run-of-mine ore to the mill at the desired grade (about 1¾ pct), a good deal of rock that would normally be classified as ore went to the waste dumps.

During the years 1918 and 1919, much time and effort were devoted to the problem of avoiding this unnecessary depletion of reserves as well as the dilution of the ore which high bank mining rendered almost inevitable. Such ideas as leaching in place or leaching the dumps were duly considered and rejected. A scheme that appeared feasible for a while consisted of locating a primary crushing plant at a site between the mine and the mill with a 500,000-



The roll crusher house (foreground) and loading-discharge bridge (rear) as they appeared on September 9, 1914.

ton capacity graded ore stockpile which could be tapped for any desired grade from about 1 pct to 2¼ pct. Such a pile would be used to supplement the daily run-of-mine ore to maintain a uniform grade of ore required for proper plant operation equilibrium.

In 1919 several months were spent developing two alternate schemes proposed by the general manager, H. C. Bellinger. Each plan would have employed three 60-in. gyratory crushers (not known to be built at that time) feeding to nine McCully No. 10 gyratories, as well as the stockpiling of approximately one-half million tons of graded ore. However, the idea of abandoning high bank mining in favor of low bank began to evolve at this time. By 1923 when The Anaconda Co. took over the operation, the process of conversion was beginning. This change in the mining operation largely solved the problems of ore dilution, of stabilizing the daily run-of-mine grade, and of improving mining safety. This change, of course, eliminated the blasting tunnels which would have been uneconomical with low bank mining operations.

At the plant site, many features included in the original design were scrapped during the first few years of operation. The roll crushers proved themselves unable to maintain consistent sizings required for maximum extraction in the leaching plant. This problem was due to rapidly corrugating shells, probably as a result of inferior manganese used during World War I. They were replaced with 48-in. Symons vertical discs in 1916 and 1917 which allowed 12 discs for the eight rolls.

Due to a number of factors, the dechloridizing plant was scrapped and replaced with other equipment to permit iron precipitation of cement copper. While it meant combing the countryside for tin cans and scrap iron, it proved the lesser of two evils. It was also found that fouling of the leaching solutions by iron dissolved from the tank house anodes, and the build-up of the arsenic content required wasting more acid than could possibly be regenerated from the ore. This necessitated the reconstruction of the acid plant.

The tank house also had many troubles, the principal one in the early years being the scaling-off of the original magnetite anodes which had been supplied from Germany. These anodes were scrapped in favor of a ferrosilicon anode termed *durion*.

Similarly, the tailings conveyor system proved too costly in maintenance and lost time and was replaced with a railroad haulage method.

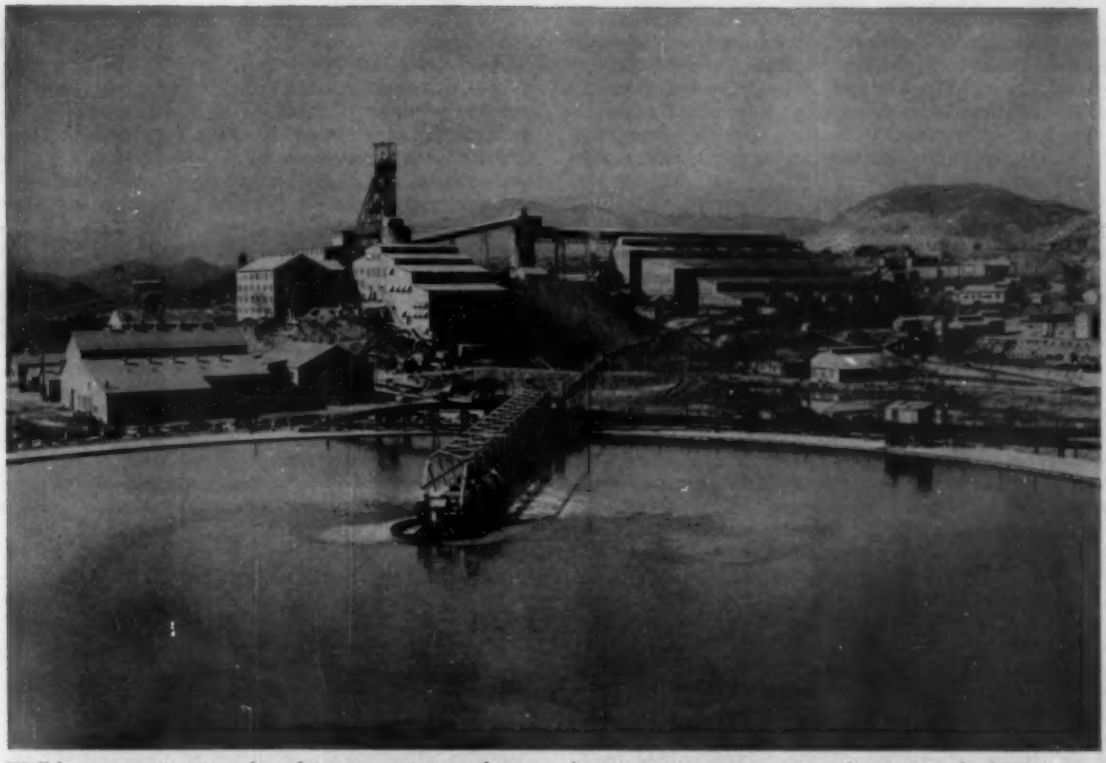
In addition to the above problems, the original treatment of the cuprous chloride had so deluged the camp area with chlorine smoke from a small blast furnace that a serious health problem was created. The subsequent installation of a bag house in late 1915 and a Cotrell plant in 1916 did little to alleviate this situation. However, the substitution of the iron precipitation plant largely eliminated this situation.

One of the many management headaches during this period concerned a shipment of 300 tons of dynamite from the U.S. in 1918. The explosives had evidently been stored too close to the ship's boiler room, and it was not until the shipment had been placed in one of the 500-ton capacity magazines in the hills above the mine that leakage of nitroglycerine was discovered. The shipment was extremely sensitive and was condemed by the supplier's representative. Instructions were given to transfer the entire shipment by burros to a wash behind a distant hill where the boxes were stacked in 10-case piles 150 ft apart and then detonated. This operation was conducted secretly with every possible precaution to insure safety, especially the safety of those not involved in the operation. Only after it was completed did the rest of the camp learn what had happened.

SUMMARY

It is only slightly more than 50 years since U.S. mining interests have "gone foreign", but I think American mining engineers can take pride in what they have accomplished in such a short span of time. Mr. A. B. Parsons, in his very interesting book entitled *The Porphyry Coppers of 1956* (AIME), said that Chuqui "alumni" appear to take pride in their "alma mater". How right he is. At least I think I can say for my generation, that while we had to put up with conditions that later graduates would not tolerate, we saw nothing unusual in them. When the job was over, the feeling of having contributed something to what was then a gigantic undertaking was its own reward.

In 1915, this building was the smelter at Chuquicamata.



Well-known to American beneficiation engineers, this was the scene of two successive applications of the LPF process.

LPF AT MIAMI

ANALYSIS OF LATEST OPERATIONS

by J. J. BEAN

The leach-precipitation-flotation process for handling mixed sulfide-oxide copper ores at Miami's mill, first used in the period 1934 to 1943, was re-established during 1957 to 1958. The following pages contain a review of the LPF process and its latest use at this site.

Concentrating mixed sulfide-oxide copper ores by the leach-precipitation-flotation method is an old operation at the Miami Copper Co. The idea was conceived and the method developed at Miami by F. W. Maclennan and Harmon Keyes during the years 1929 to 1934, and it was these men who gave the term *LPF* to this process.

Miami at that time had considerable reserves of mixed sulfide-oxide ore.* In the development of a suitable treatment method, it was natural that leaching of the oxides with acid and the precipitation of copper from the resulting copper sulfate solution by iron was investigated. The separation

* The term oxide as used in this article includes the copper oxides, carbonates, and silicates.

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of the solution from the leached solids presented an apparently insurmountable problem until the idea of recovering the precipitated copper and accompanying sulfide minerals by froth flotation was investigated. This process was ultimately developed into a commercial scale operation which successfully treated 9,790,683 tons of ore between 1934 and 1943.

The process consisted of grinding the ore sufficiently to release the sulfide minerals by floating them off in a normal alkaline sulfide-flotation circuit using sodium ethyl xanthate as the collector, pine oil as the frother, and burned lime for alkalinity. The sulfide rougher concentrate so produced was given the required cleaning and filtering, and then shipped to the smelter. The sulfide rougher tails, in which chrysocolla was the principal copper mineral, were thickened to 40 to 50 pct solids and leached with sulfuric acid in standard Dorr air-lift-type agitators. The copper in the leached pulp was then precipitated in drum-type agitators. These were wooden drums revolving horizontally on their cylindrical axes and partially filled with scrap iron from shredded tin cans that had been "de-tinned" by burning. The precipitated pulp was then pumped to a second group of flotation machines where the precipitated or cement copper, together with some of the sulfides that had not been removed in the sulfide float, were recovered. This operation used Minerec "A" as the collector, pine oil for the frother, and milk of lime for acidity adjustment.

With the exhaustion of the mixed sulfide-oxide orebody in 1943, the plant was shut down. The flotation machines were returned to sulfide flotation, and the precipitating drums were altered slightly and used to precipitate solutions resulting from the "in place leaching" which was started at that time.

LPF: 1957-1958

A new era of mining low-grade mixed ores at Miami was begun in 1954. Based on the past performance of the mill and the expected ratio of oxide-to-sulfide minerals, it was assumed that 40 pct of the oxide copper would be recoverd automatically in the course of sulfide flotation. It was recognized that, whatever oxide copper was recovered, it would be largely middling particles since the principal oxide copper mineral in the deposit was chrysocolla. Unfortunately, when mining was begun the dilution of mixed ore by the overlying essentially oxidized capping was considerably more than had been anticipated, and there was a corresponding increase in oxide copper as compared to sulfides in the mill feed. While some malachite, azurite and cuprite did float of themselves, the chrysocolla did not. Since the latter mineral predominated, the overall recovery of oxide copper was disappointingly low.

To improve the situation, determined efforts were made to sulfidize the oxide minerals with sodium sulfide and thus recover them concurrently with the sulfide minerals. This approach proved unsuccessful and was abandoned. Similarly a wide variety of reagents and flow sheets were tried in an attempt to float the oxide copper along with the sulfide. In spite of such efforts there was little or no improvement in overall copper recovery.

After both mill and laboratory testing of similar reagents and flow sheets had demonstrated that concurrent flotation of sulfides and oxides held little promise, attention was directed to a two-circuit approach in which the sulfide minerals would be floated first and followed by recovery of the oxide minerals. Because of its simplicity of equipment, direct flotation of the oxides after sulfide flotation was first attempted by using all of the generally ac-

View of the ball mill aisle in Miami's mill.

cepted techniques and reagents. This work was done with mill tailings, to avoid the sulfide flotation step. The most encouraging and interesting results were those obtained by sulfidizing the oxides in stages with sodium sulfide and using amyl xanthate as the collector, also in stages. This approach made good recoveries in the rougher concentrate stage. However, this material was low grade and could only be increased to about 7 pct Cu by flotation alone.

In the attempt to produce commercial grade concentrations by direct flotation, the LPF approach was applied to the rougher concentrates made by the sodium sulfide-amyl xanthate technique. It proved so effective that it was decided to investigate the direct application of *LPF* to the sulfide rougher mill tails. The direct *LPF* approach was successful at once. After investigating a number of possible flow sheets and other variables, the final flow sheet became a virtual duplicate of that used at Miami during the period 1935-1942.

Laboratory Procedures: The laboratory method was as follows: sulfide tailings from the 325-ft tailings thickener were agitated for 30 min with sufficient sulfuric acid to give a pH of 1.5; the copper in solution was then precipitated by adding powdered iron and agitating the pulp for 5 min; the precipitated pulp was floated in either an air-type laboratory flotation machine or a Fagergren laboratory flotation machine, using Minerec "A" and Z-6 xanthate as collectors and methyl isobutyl carbinol as the frother.

As soon as a standard test routine was established, daily tests on mill tail samples were made for one month. These tests indicated that the method was applicable to all the types of ore encountered during that month. Weekly tests made on composite samples cut during the week from the underflow of the 325-ft thickener also demonstrated that the process was suitable.

In a course of a survey conducted to determine the economic feasibility of this operation, it became apparent that it would be desirable to divide the ore into two classes, approximately 50 pct to be a relatively low oxide ore not requiring *LPF* treatment, the remainder having a relatively high oxide ore content which would be given LPF treatment. Because the flow sheet finally developed in the laboratory was a virtual duplicate of that used in the 1935-1942 period, such a split would have the additional advantage of allowing the use of the old equipment, much of which was of the proper capacity, still in place and available for use.

On April 16, 1957, operation of the *LPF* circuit started and continued with only normal interruptions until March 31, 1959, when the low price of copper forced its termination. The ore treated was mixed assaying about 0.4 pct sulfide copper and 0.5 pct non-sulfide copper, principally chrysocolla.

Sulfide Flotation: Two grinding sections were assigned to the mixed (or LPF) ore and three to the sulfide ore. Initial feed rate for mixed ore was 4800 tpd, but was quickly raised to 6000 tpd.

For years roughing flotation in the Miami mill was conducted in two essentially identical sections known as the *A* side and the *B* side. Each side had three 100-ft Miami roughers, and three 15-ft cleaners. In addition, the *B* side of the mill had two half cells equivalent to one 100-ft cell.

The *A* side of the mill was assigned to the *LPF* operation, one 100-ft cell being used as a sulfide rougher and the other two 100-ft cells as cement copper roughers. The sulfide rougher concentrate joined that of the *B* side of the mill, and went to the retreatment plant and thence to the molybdenum plant for molybdenum recovery. The desire to recover the molybdenum contained in the mixed ore sulfide concentrate was the principal reason for making separate sulfide and cement copper floats. The laboratory work had indicated that both the sulfide minerals and the cement copper could be floated readily in a single flotation step if desired.

When tonnage was increased to 6000 tpd, more cement copper flotation time was required. The mixed ore sulfide flotation was transferred to a rougher on the *B* side of the mill, leaving three roughers available for cement copper flotation on the *A* side. At the same time, additional half-cell roughers were placed in the sulfide ore circuit on the *B*-side to increase capacity.

Thickening: The tailings from the mixed ore rougher cell, approximately 25 pct solids, flowed in a 16-in transite pipe to a drop box at the north end of the mill, thence by gravity through a 16-in transite pipe to a 180-ft diam Dorr torque-type thickener. The thickener overflow joined the main mill water circuit while the underflow (about 42 to 48 pct solids) was pumped to the leaching agitators.

Leaching: Leaching was done in three air-lift-type agitators measuring 20-ft deep with 30-ft diam that remained from the earlier *LPF* operation. Pulp from the 180-ft thickener discharged from a transite pipe into a wooden weir box, and thence into a launder system which allowed any agitator tank to be cut out by simply changing gates in the launder. Normally all three agitators were operated in series.

Sulfuric acid was fed into the pulp stream immediately behind the measuring weir. Since the acid entered the pulp ahead of the distributing launder, no change in the point of addition was required, regardless of the particular agitator arrangement being used. Commercial sulfuric acid, obtained largely from Kennecott Copper Corp.'s plant at Hayden, Ariz., was used.

Although higher and lower pH's were tried, experience proved that if the pH of the first agitator discharge was held at 1.7, leaching was completely satisfactory. At this initial pH, the discharge of the third tank had an approximate pH of 2.3.

Generally the operation of the airlift agitators was satisfactory, and leaching gave very little trouble. The probable reason was the amount of leaching time. While the laboratory work indicated a 30 min. contact of leaching solutions with the

The precipitation drum used in Miami's LPF circuit.

pulp, there was actually closer to 3½ hours of contact in the three agitators. Sampling and assaying indicated one agitator did not complete the leaching, probably because of short circuiting. It is believed that had there been three small agitators in series with their total volume being that of the one large agitator, good leaching would also have resulted.

Precipitation: The pulp flowed from the leaching tanks through an 18-in pipe to the precipitation drums. Milk of lime fed into the pipeline raised the pH of the pulp to 2.9 to 3.0. Considerable saving in iron resulted from this addition since free acid was reduced from approximately 2.0 lb per ton of solution to 0.5 lb.

The limed pulp entered a distributor box where, by means of gates, it could be sent to either or both precipitating drums. The feed entered the drums from an elevated box. The shredded iron for precipitation was washed into the drum by the entering feed.

Generally speaking this feeding arrangement was reasonably satisfactory except when oversized pieces shredded iron were used or when a large amount of wire was present. Plugging of the feed entry resulted from either of these conditions requiring the drum to be shut down, the inspection door removed, the drum dumped, and the plugging material removed. Such a proceeding resulted in at least four hours of lost time plus a considerable amount of labor in reclaiming and cleaning the dumped iron. There was also some loss of copper in solution.

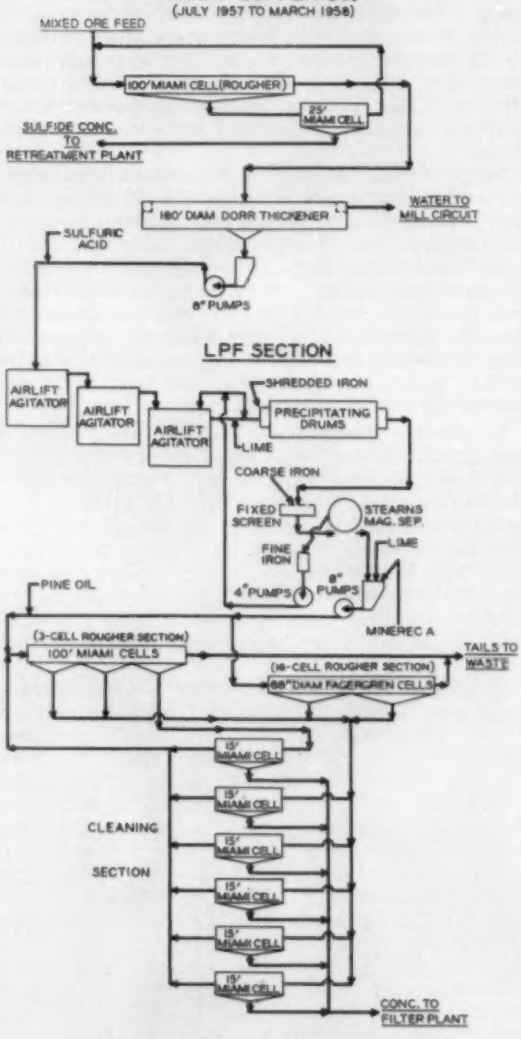
The drums had 9-ft ID and were 28-ft long. They were of wood stave construction with rubber lining, the rubber being protected by stainless steel sheeting. Four longitudinal wooden lifters protected with stainless steel sheeting were provided to reduce abrasion of the stainless lining by the shredded iron. The drums were driven by a 100-hp motor at a speed of 8 rpm.

To maintain a full load of scrap iron in the drum at all times, the initial practice was for a man to feel the iron with a "feeler" rod. This proved thoroughly unreliable and an ammeter was installed on each drum motor. Thereafter the drum was fed to maintain a specific current reading.

The current reading was hardly sensitive enough to insure near-maximum precipitation, so it was supplemented by an actual determination of copper in solution in the drum discharge pulp. Several schemes to determine copper in solution were tried until a satisfactory method was evolved. Each hour the leach tank operator would take a small sample of drum discharge pulp, filter it, dilute the filtrate at 10:1 ratio, measure out 10 cc into a colorimeter cell, add a few drops of both dilute sulfuric acid and a sodium sulfide solution. The resultant turbidity was read on a colorimeter calibrated to permit direct reading of "lb of copper per ton of solution." This so-called "color copper" was the main controlling factor, and iron was added to the drum until either a suitable low content of copper in solution resulted or the amperage of the drum motor became too high for safe operation. By means of these two controls, the barren solution was easily held at 0.04 lb of copper per ton.

Magnetic Separation: The drum discharge passed first over a stainless steel screen with 1-sq in. openings to permit removal of over-size iron. This was a manual operation and presented a small problem since the men were prone to leave it alone as long as possible.

SCHEMATIC FLOWSHEET
LEACH-PRECIPITATION-FLOTATION PROCESS
MIAMI COPPER CO.
(JULY 1957 TO MARCH 1958)



The screen underflow passed under a 48x48-in. Stearns single pole magnetic separator turning at 20 rpm. This separator removed magnetic iron from the pulp stream and discharged it into a pump box, thence into a Wilfley pump which had been modified to provide for top feeding. A stream of pulp was also diverted into the pump feed, and the iron and pulp were then pumped to either the head of the precipitating drums or to the No. 3 leaching agitator, as described earlier.

The pulp after passing under the magnetic separator traveled by gravity to a pump box where sufficient milk of lime was added to maintain a pH of 4.5 to 4.9, which both laboratory and mill testing indicated to be satisfactory. Minerec A was added to the pump box and the pulp sent to the cement copper rougher flotation section.

Flotation: At the start of operations two rougher cells were used as cement copper roughers; later when the tonnage was increased, a third cell was added. These cells were all standard 100' Miami-

type air cells. Their froth launders were divided into three 33-ft sections.

Originally the froth caught in the first two sections near the head of the machine was combined and pumped to two parallel 15-ft Miami-type cleaners. The froth in the third section ran to a separate pump box and went to another 15-ft Miami-type cleaner. The tails from all the cleaner cells flowed by gravity to the head of the rougher flotation section.

When the tonnage was increased and the third rougher cell was added, three additional 15-ft Miami cells were added to the cleaning section. The concentrate from the third section was cleaned in two other cleaner cells. As before, all cleaner tails flowed by gravity to the head of the roughers. The cleaner concentrates were combined into one final cement copper concentrate and sent to the filter plant, where they were filtered and loaded separately from the sulfide concentrates.

PROCESS IMPROVEMENTS IN PRECIPITATION AND FLOTATION IN LPF CIRCUIT

Precipitation Stage: Precipitation was, of course, a vital part of the process since any copper not precipitated was lost. Accordingly a great deal of time and effort was spent improving this step of the *LPF* process. At the start of operations, coarsely shredded tin can scrap was used. Even when the drum was filled to the choking point with this iron, precipitation was poor. As much as 0.4 lb of dissolved copper per ton of solution would remain in the drum discharge pulp.

Also, poorly burnt iron was a poor precipitant. Occasionally the cans appeared burned but were actually little more than just smoked. Although tin will precipitate copper, it is slower in such action than iron. Furthermore, the lacquers used to line tin cans and the lithographing on the outside of such cans will slow down or entirely prevent precipitation.

When these factors were finally recognized, a trommel with 1½-in. openings and a finer screen were installed in the hammer mill. When this screened iron became available, precipitation improved. Naturally the finer shredded material lessened the problem of choking in either the drum feed opening or the discharge.

A peculiarity of drum precipitation is the build-up of copper accretions within the drum. Copper will nucleate about a small piece of iron and, over a period of time, build up particles varying in weight from a fraction of an ounce to more than 1 lb in extreme instances. Their presence in the drum reduces precipitation efficiency and necessitates emptying the drum to dispose of the copper accretions. For disposing of accretions or for unplugging each drum was provided with a manhole in its cylindrical portion. When the drum was dumped, a plug extending through the manhole was first removed to release hydrogen which occasionally built up to a pressure of 1-lb per sq in. or more (particularly if the drum was plugged). The manhole was then opened and the drum rotated while a stream of water was run into it. The iron and copper discharged from the manhole during the low part of the revolution was caught in a wooden bin under the drum. Before restarting the emptied drum, as much fresh iron as possible was charged through the door. The door was then replaced, the drum started, and shredded iron fed as rapidly as possible from the belt until normal precipitation was restored.

The iron in the bin beneath the drum was recovered through a trap door in the bin bottom which discharged into a short conveyor. This second conveyor passed around a magnetic head pulley allowing the copper and other non-magnetics to drop into one bin while retaining the iron for discharge into another bin. Periodically this iron was returned to the main receiving bin for reuse, and the copper was shipped to the smelter.

One other effective method employed in improving copper precipitation was to return the fine iron removed magnetically from the drum discharge to the No. 3 leaching agitator. This iron, which was easily handled by the airlifts and rakes of the agitators, precipitated from 2 to 3 lb of copper per ton of solution in the agitator. This precipitation of copper took some of the load off the overworked drums and contributed considerably to good operation.

At one time "notchings" from tin can manufacture were fed directly to the No. 3 agitator. They worked well and seemed to be an ideal precipitant, but unfortunately, were not available in sufficient quantities to charge even one drum. They might have produced some remarkable results.

Too much emphasis cannot be placed on the desirability of good precipitation for, in addition to the direct loss of soluble copper resulting from poor precipitation, there was evidence that copper remaining in solution had a deleterious effect on subsequent flotation.

Flotation Stage: Rougher flotation was critical to the entire operation and required close, constant supervision. This was due in part to the continued lack of enough flotation machine capacity to permit 10 min roughing time, as the laboratory work had indicated was needed. The short flotation time was

Table I. Mixed Ore Copper Production, 1957 to 1958

	Sulfide	LPF	Overall Results
Feed:			Initial Feed
Dry Tons Ore	1,105,600	1,092,961	1,105,600
Total Cu, pct	0.877	0.551	0.877
Cu Oxide, pct	0.500	0.463	0.500
Cu Sulfide, pct	0.377	0.088	0.377
Tailings:			Final Tailings
Dry Tons Ore	1,092,961	1,082,034	1,082,034
Total Cu, pct	0.551	0.187	0.187
Cu Oxide, pct	0.463	0.123	0.123
Cu Sulfide, pct	0.088	0.047	0.047
Cu in solution, pct	—	0.017	0.017
Concentrate:			Total Recovery
Dry Tons	12,640	10,927	23,567
Cu, pct	29.120	36.591	32.584
Extraction:			
Cu extracted, gross lb	7,361,550	7,996,431	15,357,981
Cu extracted, net lb	7,140,706	7,741,386	14,882,092
Gross extraction, pct	37.80	66.40	79.13
Net extraction, pct	36.75	64.27	76.72
Gross lb Cu extracted per ton feed	6.658	7.316	13.891
Net lb Cu extracted per ton feed	6.459	7.083	13.460
Ratio of Concentration	87.6	100.0	47.0
Operating Days	255	255	255

Reagents (LPF only)	Lb per Ton Feed	Lb per Net lb of Copper
Sulfuric Acid	29.50	4.176
Burned Scrap Iron	10.24	1.448
Burned lime	2.22	0.328
Minerec A	0.097	—
Pine Oil	0.05 (estimate)	—

Dorr bowl classifiers (left) and the 100-ft Miami-type roughers (right) which were used for both sulfide and LPF flotation.

somewhat improved with the addition of the third cell, but even then, the flotation stage seldom exceeded 5 min.

Flotation was hindered also by the presence in the cement flotation feed of rather large amounts of fine iron which had escaped the magnetic separator. This iron probably assisted in preventing re-solution losses, but it also was deposited in the bottoms of the cells and interfered with the air dispersion from the air pipes.

Because of these two reasons, and perhaps others, the tailings produced by the air cells in the mill never equalled those made in the laboratory. The difference between the mill air cells and those of the laboratory was due probably to the more vigorous aeration which the laboratory cell could achieve. Because turbo-blowers are used for mill air supply, it was impossible to increase mill cell aeration by increasing the air pressure to the cells.

When it became apparent that air cells alone would not achieve the desired low copper content tails, eight 20-in Fagergren cells were installed to treat a portion of either the cement copper feed or the tails from the air cells. They demonstrated that it was possible to produce continuously tailings of 0.07 to 0.08 pct copper made in previous laboratory batch tests.

As a result of this small scale testing, two 8-cell rows of 66-in. Fagergren machines were installed to handle the cement copper feed. Because these machines had steel tanks which would be subject to both corrosion and abrasion, they were sand blasted and given five coats of plastic base paint. In those places where abrasion would be greatest the steel was covered with Linatex. For simplicity of operation, all the rougher concentrate produced by these cells was combined with the concentrates from the first two sections of the air cells and sent to the cleaning section. The reduction in tonnage to the air cells resulted in improved tailings from them, but they were still substantially higher in copper content than tailings from the Fagergren cells. The average of both, however, was an improvement over the tailings from the air cells alone.

The cement copper concentrates were shipped to the Phelps Dodge smelter at Douglas, and after a short operation period, the smelter requested that higher grade concentrates be shipped. By simply slowing down the cleaner cells and with close supervision, the copper concentrate grade was raised from the 30 pct to 40 pct without any discernible difference in the final tailing. Had equipment been available, it is possible that a second cleaning step could have been included in the operation and concentrates exceeding 50 pct Cu made.

SUMMARY

Good metallurgy was largely a matter of good precipitation, alkalinity control in rougher cement copper flotation, and keeping the cement copper roughers running fast enough. The cleaning step gave no trouble, for it seemed that once the copper floated, it continued to float.

The control of acid in the leaching agitators was important, but if the pH was kept below 1.75, good extraction usually resulted. Lower pH's than the normal 1.70 were tried but had little effect on the copper content of the tailings.

A summary of the whole period of *LPF* operation is given in Table I. This table gives the metallurgy of both the sulfide and oxide flotation steps, as well as the combined results of both steps. The reagents for the sulfide step were inextricably bound up with those used in the section treating low oxide ore.

PORTABLE CRUSHER FOR OPEN PIT AND QUARRY OPERATIONS

by B. J. KOCHANOWSKY

The idea of a portable crusher is not new. Many such crushers are available but they are small and designed for construction work. For many years the author has suggested, both in this country and in Europe, the building of larger portable crushers intended expressly for use in quarries or open pits. Although not applicable under all conditions, there are mining operations where a mobile crusher arrangement could be more profitable than the facilities now used.

The primary use of a portable crusher, i.e., a crusher mounted on crawlers or tires, in the rock and mining industries is to reduce costs by permitting the substitution of conveyor belt haulage for truck or track haulage. The usual sequence of operations in surface mining is drilling, blasting, loading, haulage, and crushing. Haulage is normally accomplished by truck or track-mounted cars, the latter method being used for the longer distances. However, by using a portable crusher in the pit, the sequence of operations would be changed so that the crushing stage would occur before haulage (Fig. 1). Such a sequence would permit the use of conveyors to replace the more expensive truck or track haulage methods.

Since most quarry and open pit operations normally require a crushing stage, the only additional costs incurred will be due to the investment required to purchase or construct a mobile arrangement for a crusher. But this factor has to be weighed against the advantages to be gained by conveyor haulage. As shown in Fig. 2, transportation of material by belt conveyor over short distances is less expensive than by truck. The inclination of the belt has no effect on belt speed; consequently, the hourly tonnage moved remains the same. Conversely, the output rate of trucks as expressed in tons or ton-miles per shift decreases proportionally to the haulage speed, which is considerably slowed by the steepness of the road (Fig. 3a). Although maximum possible grades and maximum economic grades of haulage are greater for a belt than for a truck (over the same total lift), the longer haulage distances favor the use of trucks.

Although power consumption for hauling on a grade increases for both conveyances, the rate of power consumption increases faster for trucks than for conveyor belts (Fig. 3b). Since the output rate and related fixed costs are affected by the travel speed, total haulage costs with trucks would increase with the grade more rapidly than the similar costs of conveyor belts (Fig. 4). Travel distance, road grade, speed, size and number of pieces of equipment, efficiency of operation, and many other factors affect such haulage costs. In general terms it can be said that the shorter the distance, the steeper the grade, and the greater the output, the more advantageous the belt becomes in comparison to truck or track haulage.

In addition to potential cost savings in haulage procedures, a portable crusher would allow better utilization and performance of shovels. Loading operations would not be interrupted as often by the necessity of waiting for cars or trucks. Unfortunately, the application of belts in open pits for haulage from bench sites is generally not practical under existing conditions because a belt fed directly by a mechanical shovel can be torn, damaged, or worn out quickly by the large rock fragments falling on it during loading. However, by using a mobile crusher this situation can be avoided. As shown in Fig. 1(b), the shovel feeds rock into the crusher located behind it. The crushed material is initially transported by an extensible and/or movable belt, thence by a longer stationary conveyor to the plant where the material is subjected to further treatment by secondary crushing, screening, etc. The first-mentioned conveyor, needed to bridge the distance between the shovel and the stationary conveyor, is necessarily variable in length owing to the continuous movement of the shovel and the desire to keep the stationary belt at a safe distance from the bench during blasting operations.

The remarkable part of mobile crusher operations is the extra-ordinarily high output per man-shift, the low maintenance and power requirements for haulage, and the increased output of the loading

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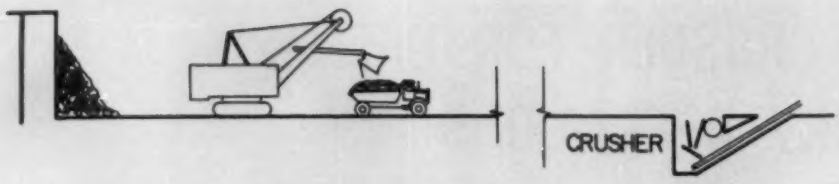
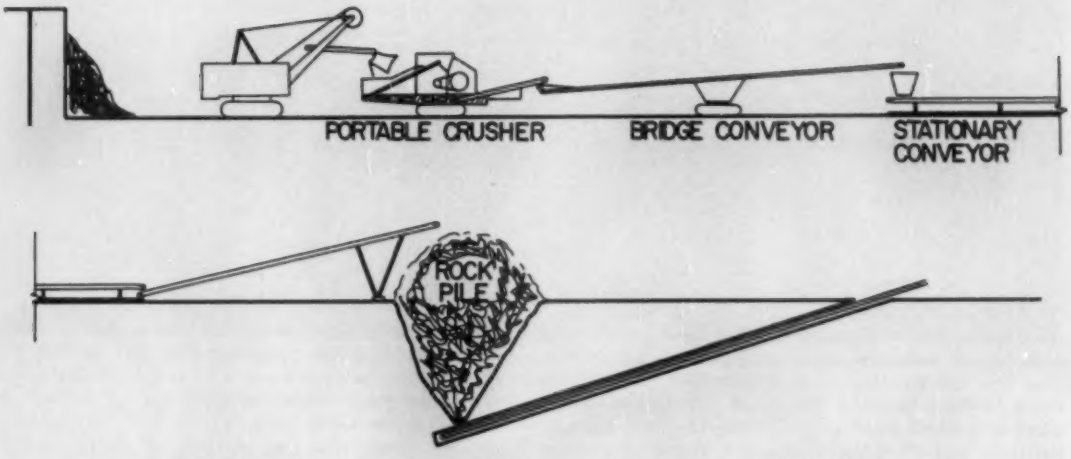


(a) SURFACE MINING WITH CONVENTIONAL EQUIPMENT



(b) SURFACE MINING WITH PORTABLE CRUSHER AND CONVEYORS

Fig. 1

shovel. A cement quarry which has been using a portable crusher and conveyor since 1956 requires only three men to operate the shovel and crusher and to transport the crushed rock by belt from the quarry face to the screening plant. If truck haulage were used, six men would be required. Rock fragments up to 30-in. in size are fed into a hammer crusher which operates at an average rate of 165 tph. On occasion, the crusher's output has reached 250 tph. At this quarry, the bridge and stationary conveyors are 24-in. wide and travel at 250 fpm. The 1460-ft long stationary belt lifts the material 140 ft and consumes 0.17 kw-hr per ton of rock. Since a portable crusher has been installed, the shovel loading time, as well as its output, has increased 50 pct. By employing a larger shovel and portable crusher with the same three men, possibly two or three times the tonnage could be moved.

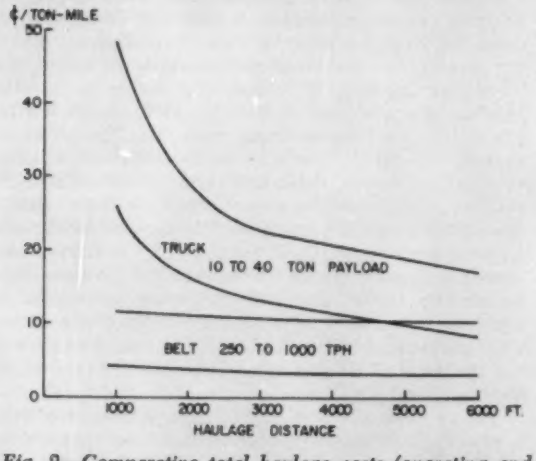


Fig. 2—Comparative total haulage costs (operating and ownership costs) of trucks and conveyors on level grade.

Another company employs a portable impact crusher to reduce 30-in. rock to 3-in. size. This crusher is mounted on rubber tires and moved by the mechanical shovel itself. The capacity per hour of the crusher and belt, as well as the arrangement of facilities, are similar to the first quarry described. As was also true in the first operation, shovel loading time has been increased 50 pct.

PORTABLE IMPACT CRUSHERS

Gyratory, jaw, roll, hammer, and impact crushers can be used in a portable arrangement. Of all these types, the highest crushing capacity can be obtained with a gyratory crusher, but its height and necessary heavy foundation are disadvantages for its use as a mobile crusher.

On the other hand, impact crushers lend themselves well to portable operations. Such crushers

have high capacities, are relatively lightweight, have small foundations, and usually generate less vibration during crushing operations. In addition, power consumption, which depends on the ratio of rock reduction, is quite low in this type of crusher. Crushing dolomite from 46 in. to 3½ in. (13:1 reduction ratio) requires 0.33 kw-hr per ton, and for a 5:1 reduction ratio, 0.18 kw-hr per ton.

An increase in crusher capacity can be obtained by providing a grizzly to separate the larger pieces of rock from the smaller ones so that only a part of the material loaded by shovel need go to the crusher. The smaller sizes can be loaded first on the conveyor to provide a cushion for the larger fragments of rock.

BENEFITS FROM MOBILE CRUSHERS

As previously noted, the use of a portable crusher would increase the performance of a loading shovel and thereby decrease the number of shovels required to maintain the same rate of production. However, there are quarries where rock must be taken from different parts of the pit and mixed together in order to get a desirable composition. This is usually done in cement quarries. For such cases, storage of material at the end of the stationary conveyor or along its route is suggested, where the desirable mixture of product could be achieved. This would also create a buffer supply and allow daily quarry operations to be independent of the immediate needs of the plant and of the interruptions in the plant which usually affect the performance of the shovels. Such use of stockpiles could aid in increasing the performance of each shovel during its operating time.

In quarries or open pits, if each shovel in operation eventually required one portable crusher, such a project might not be feasible due to the large number of portable crushers required. However, in quarries where portable crushers have been introduced, the whole production is delivered by one shovel only, producing 150 to 250 tph. There are many quarries attaining such production. If the production needs to be greater, a shovel of larger capacity can be employed to reduce the total number of shovels and portable crushers required. Since the crusher is mobile, it can be moved from one shovel to another, so that more shovels can be used than portable crushers. If it should be possible to increase the number of working shifts per day, further reduction of the number of shovels and portable crushers is possible.

Quarries or open pits using track haulage often require a large number of workers to move the track after blasting as well as to operate the railroad switches. The use of a long-boom shovel would make it possible to increase the distance between the bench face and the track. It would also aid in reducing the amount of time now consumed in moving the track and the number of workers to do the job, but such a shovel is more expensive and slower. As an alternative, Fig. 5 shows a layout of conveyors and mobile crushers in a quarry or open pit. The stationary conveyor has to be located far enough away from the bench to avoid being damaged by flying rock from a blast. By means of an extensible and/or movable bridge conveyors, the stationary belt can be located far from the bench at a distance several times greater than the distance between the bench and track and trolley wire presently used in some open pit copper projects.

Application of the portable crusher might encourage the use of higher benches with the commensurate less blasting that would be required. Domestic practice, however, does not favor the use of high bench faces, partly for safety reasons during loading and partly because higher benches usually require a large borehole diam, larger drill, etc. Inclined drilling might solve such blasting problems because it reduces the resistance of the rock to blasting at the toe of the bench. Therefore, the footage of drillhole required and/or the explosive consumption is smaller. Furthermore, due to its inclination, the pit face is safer for operations. In most cases, inclined drilling is the only practical solution with high benches. In realization of these facts, new designs

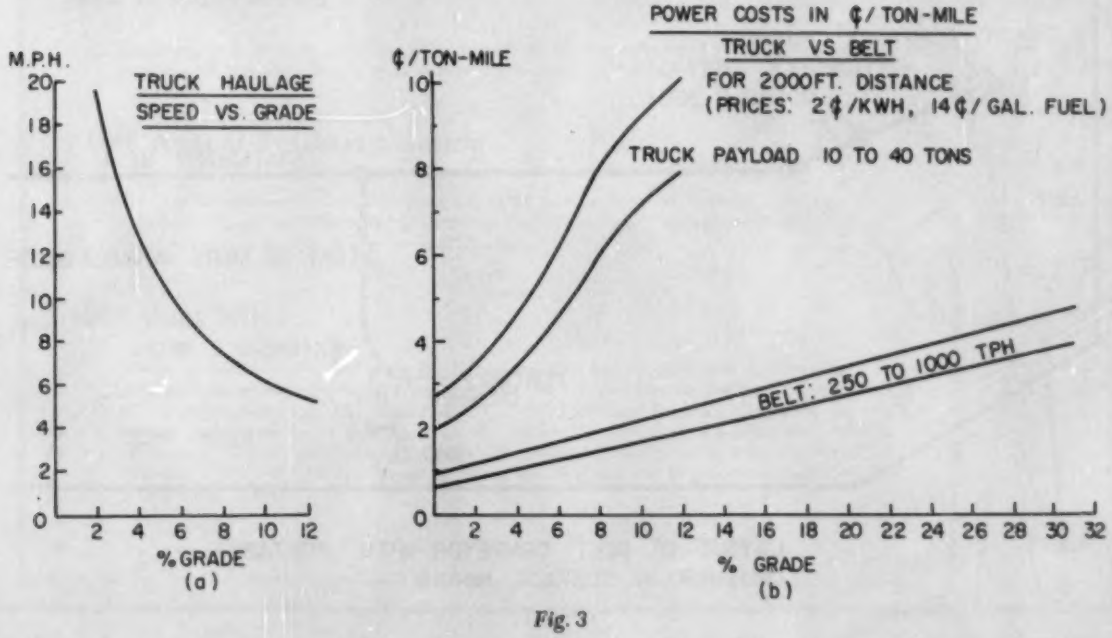


Fig. 3

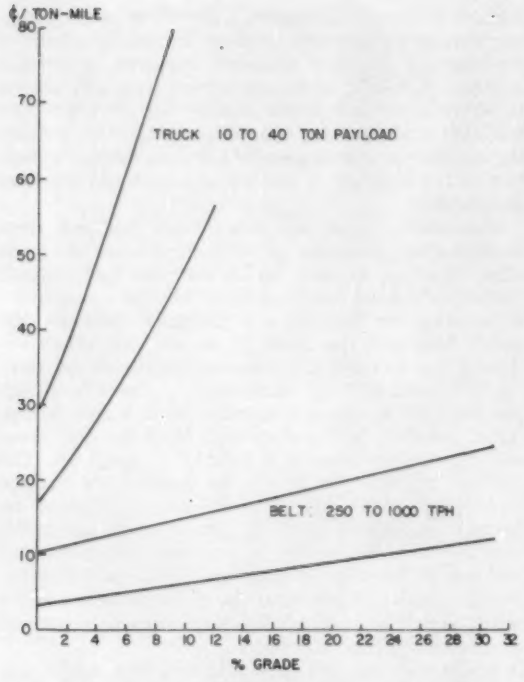


Fig. 4—Comparative total haulage costs (operating and ownership costs) of trucks and conveyors. Chart based on 2000-ft haulage distance but at different slope grades.

of drilling equipment capable of drilling inclined holes up to 9-in. diam are already on the market.

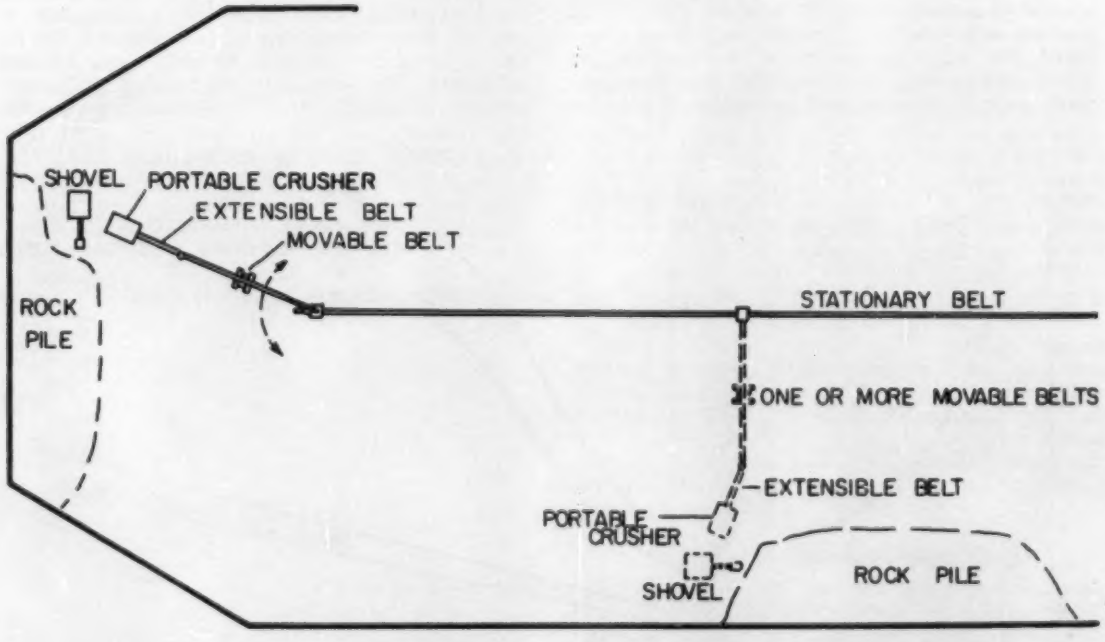
SUMMARY

Small portable crushers are available on the market. Companies which are using such crushers in their quarries consider that units of 500-tph capacity can be built and easily applied. Portable crushers have already been designed which exceed 1000-tph capacity.

Portable crushers might find application in strip mining as well as open pit and quarry operations. In coal stripping, the actual depth of operation is determined by the size of the stripping shovels. This depth limit might be altered in the future if it becomes feasible to crush all or part of the overburden and to haul the excavated material by a conveyor to the dump.

Underground mining is another field that warrants investigation of the application of a portable crusher.

The author has attempted a sketch of the possibilities of application of a portable crusher with conveyors in quarry and open pit operation. It is apparent that there are factors which are both for and against the adoption of such a scheme. Hardness and abrasiveness of the material, capacity and price of the crusher, power consumption, wear, and other factors affect the selection of a crusher. Needless to say, careful cost analysis is required in each case. Because of its ability to lower both haulage and labor costs, the use of a portable crusher is worthy of careful consideration.



LAYOUT OF BELT CONVEYOR WITH PORTABLE CRUSHER IN SURFACE MINING.

Fig. 5

SME BULLETIN BOARD

Reports of Your Technical Society

This 620-ft high stainless steel arch being erected in the Jefferson National Expansion Memorial along the river front in downtown St. Louis symbolizes not only the city's historic role as "The Gateway to the West," but also an era of civic progress unparalleled in St. Louis history. The arch is scheduled for completion in 1964—the city's 200th anniversary.

February 26—March 2

Don't forget these dates for the 90th AIME Annual Meeting! Approximately two weeks later than usual, more than 3000 members and their wives are expected to gather in St. Louis for an outstanding technical and social program. Headquarters for the meeting, site of social events, and headquarters for SME technical meetings and social events will be the Chase-Park Plaza Hotels. Reservation information and forms will be mailed to all members.

SME Board Meeting

Beginning at 9:30 a.m., Monday, February 27, an all-day meeting of the present and incoming members of the SME Board of Directors will be held in the Hunt Room of the Chase Hotel.

AIME Annual Business Meeting

The regular Annual Business Meeting of AIME will be held on Tuesday afternoon, February 28, in the Khorassan C Room of the Chase Hotel, immediately following the All-Institute Session at the Annual Meeting.

1961 Dues Bills

Notice is hereby given that dues for the year 1961 are payable Jan. 1, 1961, as follows: Members and Associate Members, $20; Junior Members for the first six years of Junior Membership, $12, and thereafter, $17; Student Members (including an annual subscription to a monthly journal), $4.50. Dues bills were mailed early in November. Prompt payment will assure uninterrupted receipt of the publications desired in 1961. If, for any reason, a bill is not received within a reasonable time, please notify AIME.

Mining Symposium Scheduled for February

An International Symposium on Mining Research, jointly sponsored by the University of Missouri School of Mines and Metallurgy and the U. S. Bureau of Mines, will be held February 22 to 25, 1961, on the School's campus in Rolla. The sixth in a series of symposiums on mining research, the conference is to be international in character and will include the following research categories: explosives and blasting, rock mechanics, and basic research applied to mining. Authors from Austria, Australia, Canada, Czechoslovakia, England, France, Germany, Japan, Sweden, and the U. S. have responded to invitations to present papers. Papers will be given in French, German, or English with concurrent translation by earphones.

For further information write to:

George B. Clark, Co-Chairman
Symposium Committee
Department of Mining Engineering
Missouri School of Mines and Metallurgy
Rolla, Mo.

Old Center Sold As New Building Rises

As the new Engineering Center draws nearer to completion—some of the limestone facing is already in place (see photograph below)—the old Center on 39th Street, a landmark for more than 50 years, has been sold. Fred Rudinger Associates has purchased the building for $2,000,000. Mr. Rudinger tentatively plans to develop the building to meet the needs of textile converters who have moved from the Worth Street area to midtown Manhattan.

AIME Actions of Special Note to SME Members

► At the Board of Directors meeting in October it was voted to designate Annual Meetings by number, beginning with the February 1961 meeting in St. Louis, which will be the 90th. The Institute was organized on May 16, 1871, and the Centennial Celebration will be held in 1971 at the time of the One Hundredth Annual Meeting.

► William C. McCulloch, Chairman-Elect, Coal Division, will serve as AIME's National Representative and Program Committee Representative for the 1961 American Power Conference by action of the executive committee taken by mail in September.

Report of SME Board Actions Taken During Recent Denver Meeting

The Board of Directors of the Society of Mining Engineers met in Denver, Colo., on October 4. Sixteen Officers and Directors attended or were represented by alternates. AIME President Joseph L. Gillson and AIME President-Elect R. R. McNaughton were each present for a part of the all-day meeting.

Important matters decided at the meeting included:

1) Acceptance of the idea of an SME Fall Meeting to be held in late summer or early fall each year. This will not be "just another meeting."

A committee was authorized to work out the details for the first meeting to be held in 1963.

Planners were instructed to seek cooperation with existing fall meetings to the end that the number of meetings is not increased and the present pattern of such meetings over the nation is strengthened.

It will bring AIME on a national scale to the mining areas of the country and thus to the younger members who now seldom attend the AIME Annual Meeting in February.

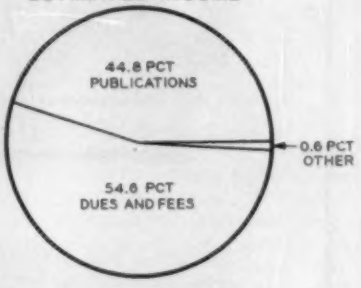
It will reduce pressure on the Annual Meeting by providing a second forum of equal importance for presentation of papers. The net result will be enhancement of both meetings.

2) Acceptance of recommendations in the progress report of the Organizing Committee for the SME Planning Committee. This committee tentatively recommended establishment of a Long Range Planning Committee that will be a planning and advisory group, without power to execute, but with privilege to communicate with any and all Directors of the Society, all SME Divisions, and all AIME Local Sections.

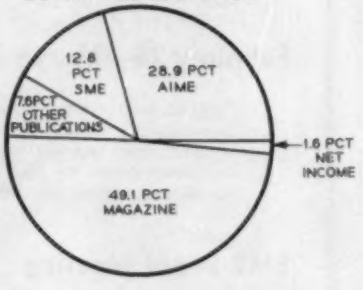
3) Approval of the SME Tentative Budget Estimate for 1961. The estimates of Society Income and Expense for 1961 are:

Dues and Fees Income	$231,600
Publications Income	190,300
Other Income	2,600
Total	$424,500
SME Share of All Institute Expense	$122,605
Society and Divisional Expense	54,765
Publications Expense	240,556
Net Income	$ 6,574

1961
ESTIMATED INCOME



1961
ESTIMATED EXPENSE



Of this net income 25 pct goes to AIME and 75 pct will be transferred to the SME Activities Fund to be held for a "rainy day."

Aid to Economy Sought for Appalachian Area

In an effort to seek solutions to unemployment and economic slowdown, the governors of nine Appalachian states or their representatives met in Lexington, Ky., October 18 and formed a regional organization. Joseph E. Moody, president of the National Coal Policy Conference, has offered the full cooperation of coal and related industries in this program. In a letter to the governors he pointed out that a prosperous coal industry is vital to the region's economy and offered to present specific proposals at the next meeting of the organization as to ways the Conference can help.

Raymond B. Ladoo to Get Hardinge Award

Raymond B. Ladoo has been named recipient of the Hal Williams Hardinge Award for 1960. He is the third person to be so honored since Mrs. Hardinge established the Award in 1958 in memory of her late husband. The Award is given in recognition of outstanding achievement in the field of industrial minerals. By his work as engineer and author, Mr. Ladoo is eminently qualified to receive this recognition.

Raymond B. Ladoo

He has long been active in the industrial minerals field, both professionally and in his association with the AIME, which he joined in 1914. He has participated in the programs and various projects of the Industrial Minerals Division since it was founded in 1935 and, prior to that, was active on the Nonmetallic Minerals Technical Committee out of which the Division grew. With the inception of SME as an independent organization, he became the Society's first Treasurer, serving in that capacity until the expiration of his term at the beginning of this year. He is presently a member of the Division's Nominating Committee.

Mr. Ladoo is a native of Ayer, Mass., and a graduate of Harvard University. He maintains an office at Newton, Mass., as an industrial minerals consulting engineer, but not all of his professional life has been spent in the Bay State. He began his career with two Virginia companies, Low Moor Iron Co. and John B. Guernsey & Co. Inc. His work with the U. S. Bureau of Mines took him to Washington, D. C., and his association with U. S. Gypsum Co. led to residence in both New York City and Chicago. Among other companies and organizations with which he has been associated before establishing his present practice are: Colorado Fluorspar Corp.; Organo Inc.; Colonial Mica Corp.; New Products Research Corp.; Nieder Fused Quartz Co.; and the War Production Board, for which he was chief of the Mica-Graphite Branch.

Mr. Ladoo is the author of the book *Nonmetallic Minerals*, which served as a model for the first edition of AIME's *Industrial Minerals and Rocks*. He was one of the editors of that volume and contributed several chapters to it and to the recently published volume of the same name edited by AIME President Joseph L. Gillson. He is also the author of numerous technical publications and is an authority on such minerals as talc and fluorspar and the economics of the nonmetallic minerals industries.

G. E. Evans to Speak at IndMD Annual Lunch

G. E. Evans, director of research for Union Carbide Corp., will be guest speaker at the Industrial Minerals Division luncheon at the Annual Meeting in St. Louis. In his address he plans to give an elementary status report on fuel cells, with emphasis on practical considerations such as performance characteristics, fuel utilization, and efficiencies. He will cover the Union Carbide fuel cell in some detail, with comments on other types for orientation and perspective.

Born in Chicago, Mr. Evans graduated from the University of Illinois in 1941 with a B.S. in chemistry. He began work on his doctorate at the State University of Iowa, where he was also a full-time instructor in physical metallurgy and taught courses for the U.S. Navy in higher mathematics, phase rule, and chemical thermodynamics.

Entering the U.S. Navy during World War II, he served for two years as communications officer with the Third Fleet.

Returning to the University of Iowa following his naval service, he continued work on his Ph.D. For a year he was assistant professor of physical chemistry and also did research on molecular structure. He received his Ph.D. in 1948.

G. E. Evans

Mr. Evans began his association with Union Carbide Corp. in 1949, when he was employed as a physicist at Oak Ridge National Laboratory. He remained there until 1953 during which time he was a group leader in research on fundamental physics and taught at the Oak Ridge School of Reactor Technology. In 1953 he was transferred to Cleveland, where he served as a group leader of the Physical Chemistry-Corrosion group. Shortly after the new Parma Research Laboratory was opened in 1956, he was appointed assistant director of research, Electrochemical Division. In October 1959, he was appointed director of Research of the newly-formed Union Carbide Consumer Products Co.

The United Electric Coal Companies
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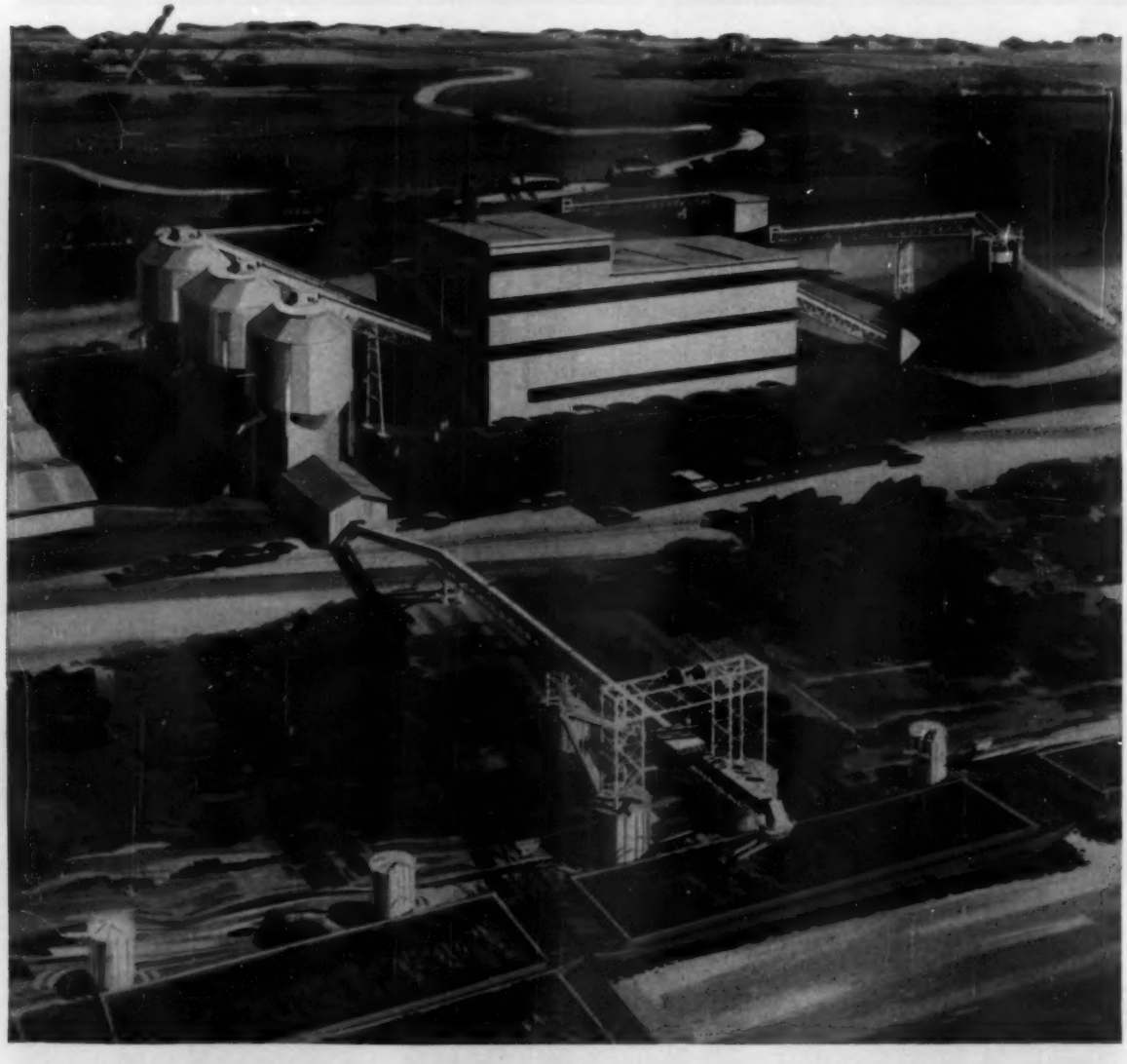

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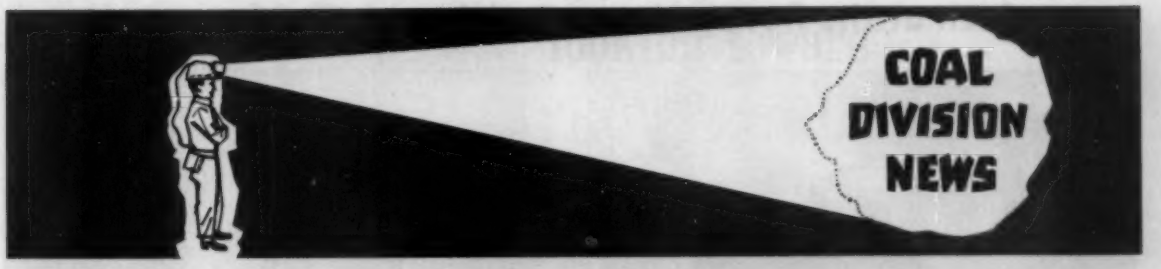

Proposed Amendments to Coal Division Bylaws

At a meeting in the Daniel Boone Hotel during the 23rd Annual Joint Solid Fuels Conference the Executive Committee of the SME Coal Division voted to amend the Division Bylaws. The proposed amendments will, it is believed, simplify the programming of papers for all the meetings in which the Division takes part.

In accordance with Division Bylaws, the proposed amendments are published below for the information of the members. Each of you is urged to study the proposed changes carefully and to come to the Annual Meeting in St. Louis next February prepared to vote on their acceptance as prescribed. In the meantime, Division Secretary George E. Keller (c/o U.S. Steel Corp., 525 William Penn Place, Pittsburgh, Pa.) will welcome any comment you care to send him by mail.

The Annual Business Meeting of the Coal Division will be held on Tuesday afternoon, February 28, 1961, in the Georgian Room at the Chase-Park Plaza Hotel in St. Louis at 4:30 pm.

Under the present Bylaws the Coal Division Program Chairman has the responsibility, with his committee, of designing the program for the Annual AIME meeting, the Joint Solid Fuels Conference, and the Annual Spring Field Meeting sponsored by the Division. In addition he must also take care of any other meetings in which the Division participates. In actuality, it has been found over the last few years that the present system is complicated and slow.

If the proposed amendments are adopted the program committee will consist of a Chairman, a Vice Chairman for each meeting in which the Division takes part, and the Chairmen of the three technical committees of the Division. It is further proposed that the Vice Chairman in charge of the Annual Meeting will previously have served as Vice Chairman—Joint Solid Fuels Conference for one year and as Vice Chairman—Field Meeting for one year. It is logical also to assume that after serving as Vice Chairman—Annual Meeting, he will advance to Program Chairman of the Division. It will be the duty of the Program Chairman of the Division to ride herd on the vice chairmen; he will see that they meet deadlines, do not work at cross-purposes, and do not duplicate each other's efforts.

It is proposed that Article VI, Committees, be amended as follows:

Section 2, which now reads:

> Each member of the Committee on Programs shall be appointed by the Division Chairman and Executive Committee to preferably serve for three years.

will be changed to read:

> The Program Committee shall consist of a chairman, a vice chairman for each meeting in which the Division will take part, and the chairman of each of the three technical committees.

Section 4, which now reads:

> After the initial organization, the chairmen and members of the respective technical committees, except the Publications Committee, shall be selected by the Chairman-Elect of the Division during the year preceding their term of office and shall be appointed at the time of the February Annual Meeting to serve for one year. Any chairman or member of these committees can succeed himself if in the opinion of the Chairman-Elect such repetition will be for the good of the Division and Institute. The Chairman of each committee of the Division can increase or decrease the number of members of these committees with the approval of the Executive Committee.

will be changed to read:

> The Chairman-Elect of the Division shall, as soon as elected, designate the chairman of each technical and service committee to assume office a year later; these chairmen shall serve as vice chairmen of their respective committees during the interim. During the year, the Chairman-Elect shall select the members of all committees, except the Program Committee, whose term of office will commence at the next Annual Meeting of the Institute. Any chairman or member of these committees may suceed himself if in the opinion of the Chairman-Elect of the Division such repetition will be good for the Division and the Institute; however, when a committee chairman is designated to succeed himself, he shall appoint a vice chairman to assist him in the interim. The chairman of each committee except the Program Committee may appoint additional members of his committee. All appointments are subject to approval of the Executive Committee.

In order to give the members sufficient time to consider the proposed changes in the Division Bylaws before the Annual Meeting in February, we have presented them in this issue of the magazine rather than running an account of the recent Joint Solid Fuels Conference. Since the Conference is of tremendous interest to all of you, we suggest you watch for the January 1961 issue of MINING ENGINEERING. We plan to bring you full coverage of this meeting in a picture-story.

Illinois Miners Hold Meeting in Springfield

The following report was received from W. A. Weimer:

"The 68th annual meeting of the Illinois Mining Institute was held October 21 at the Hotel Abraham Lincoln in Springfield, Ill. This was one of the best-attended meetings and some of the finest papers in the history of the Institute were presented during the morning and afternoon technical sessions. Four papers were presented at each session and each speaker had a discussion period at the end of his allotted time. In this group of more than 300, who are friends, it led to quite an informal meeting.

"Art Brisse was scheduled as guest speaker at the dinner; his subject, *Skulduggery at the Old Crossroads*.

"The meeting concluded the following day with a group attending the annual University of Illinois Homecoming Game at Champaign, Ill.

"The Illinois Mining Institute was founded in 1892 as a get-together of Illinois mining men for the purpose of meeting once a year to discuss mutual problems and have speakers discuss new methods, machinery, or problems and events that are of interest and would affect all of the members."

Seen at the Rocky Mountain Minerals Conference

The Salt Lake City Tribune

Miss Gene Thuli, Miss Patricia McElhattan, and Mrs. Thomas R. Harrison, from left to right, serve as models at WAIME fashion show held during Rocky Mountain Minerals Conference.

The Salt Lake City Tribune

From left to right: Mrs. John H. Cone, Mrs. James Ivers Jr., and Mrs. Clark L. Wilson watch as Mrs. Robert R. Porter models a suit for them at Salt Lake Country Club luncheon.

Fashions of the Jet Age: Rockets and Gowns

In addition to the technical sessions, which were covered in the November issue of MINING ENGINEERING, the Rocky Mountain Minerals Conference featured such diverse activities as a trip to a rocket plant and a fashion show.

On Friday, October 7, three busloads of people rode out to the Bacchus plant of Hercules Powder Co. at Magna, Utah, to see the latest developments in rocketry. The Explosives Div. of Hercules Powder Co. has had a plant near Salt Lake City since 1915 following the start of copper mining in Bingham Canyon. In March 1958 a major face-lifting was initiated with the announcement that Hercules would build a multimillion-dollar facility for the design, development, and manufacture of solid propellants for rockets. In August of that year a normal construction program was accelerated around the clock when an initial contract with the U.S. Air Force started the company to work on development of a third-stage rocket motor for the ICBM Minuteman.

Visitors saw the modern administration building with its spacious lobby and ultramodern cafeteria, then proceeded to inspect the production facilities. These included the operating building; curing bay, where a rocket motor is heat-treated for several days; rest houses, curing bays where the finished cast double-base propellant in its case is kept for varying periods of time under controlled temperature and humidity to achieve the desired plastic state; the betatron house, where the completed rocket motors undergo minute internal inspection and test; test bays, where static test firing establishes performance characteristics; and the test house, where electronic modern data-processing units record information relayed from instrumentation on the rocket in the firing bay.

Visitors came away impressed by the immensity and complexity of these modern rocket development facilities.

The Salt Lake City members of WAIME were hostesses to the women attending the Conference and entertained them at a fashion show luncheon held October 6th at the Salt Lake Country Club. Wives and daughters of Utah Section members joined with professional models to display the season's newest fashions. Mrs. D. F. McElhattan chaired the show, assisted by Mrs. Oscar Glaeser, Mrs. F. C. Green, Mrs. C. I. Berrell, Mrs. Boris Ashurkoff, Mrs. Roger Pierce, Mrs. Thomas J. Hubbard, Mrs. Joe W. Ribotto, and Mrs. Byron Townsend.

Education News

Mackay School of Mines

Participation in live mining operations during a summer course in mine surveying drew enthusiastic response from students of the Mackay School of Mines, University of Nevada, this summer. The students worked shoulder to shoulder with miners and mine timbermen, operated working equipment, and studied mining procedures on location at active mines and quarries.

Harve P. Nelson, instructor for the mining course, arranged the summer field work to include a cross section of typical western mining operations. Nine undergraduates and two graduate students participated in the trip, which took them to gold, mercury, molybdenum, and tungsten workings and provided the on-site study of a cinnabar flotation plant. At each stop the students were able to receive instruction, study, work with machinery, and absorb the atmosphere of mining life.

The course formerly took students to old abandoned mines near Reno. The new system of study on active mine location has proved to be less dangerous and more instructive,

offering far greater variety in types of mining operations. Besides giving the student actual work experience, on-site mine study introduces him to facets of the working world not covered in textbooks, gearing him at the outset of his career to situations and conditions he is bound to encounter in actual mining or in related fields of activity.

Lehigh University

Harvey A. Neville, director of the Institute of Research at Lehigh, recently announced that the University had received a $8975 grant from the Research Corp., New York. The fund is to be used to study phase relations in sulfide systems. H. Richard Gault, head of the geology department, will direct the project. The particular system to be studied under this grant will be lead-bismuth-selenium-sulfur.

Objectives of this study are to determine the phase relations in the system and then apply this information to naturally-occurring mineral systems important to the economic geologist's understanding of the origin and occurrence of ore deposits. This particular system includes galena, the important ore mineral of lead.

The grant includes support for a graduate fellow. Jared Haselton, graduate of St. Lawrence University, has been named to work with Gault on this project.

Scholarships

Union Carbide Scholarships

Morse G. Dial, chairman of the board and chief executive officer of Union Carbide Corp., announced the establishment of a Union Carbide Engineering Scholarship program. Under this program 35 colleges will receive an annual grant-in-aid and select an incoming freshman each year as Union Carbide scholar. The scholar will receive financial assistance for tuition, books, and fees for the full four or five-year academic course, provided he or she lives up to the conduct and academic requirements of the college.

Princess Coals Inc. Scholarships

The Princess Elkhorn Coal Div. of Princess Coals Inc., David, Ky., made its 16th annual scholarship awards to five graduating seniors from Floyd and Johnson County high schools. Four of the awards went to dependents of employes of the Division. The fifth award is an open scholarship.

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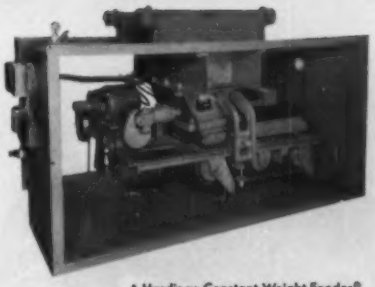
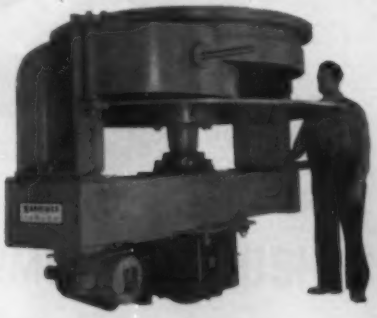
Hardinge Feeders are available in sizes and types to meet your specific requirements. Constant-Weight Feeders, Volumetric Belt Feeders, Disc Feeders and Rotary Pocket Feeders are offered. All Hardinge Feeders are suspended from feed bins or tracks and need little head room. Costly feeder support structures are unnecessary; equipment following the feeder is readily accessible. When track-mounted, one Hardinge Feeder may serve a number of bins, intermittently.

For the Hardinge Feeder story, with drawings, photos and detailed specifications, ask for 12-page bulletin No. AH-438-2.



A Hardinge Constant-Weight Feeder® mounted in a dust housing, with side covers removed. Observation windows are provided in covers. Note track-mounting wheels at top.



84-inch diameter Hardinge Disc Feeder for installation in a lime and cement plant.

Extra-long (96 inch) conveyor type Hardinge Volumetric Belt Feeder designed for bin mounting.

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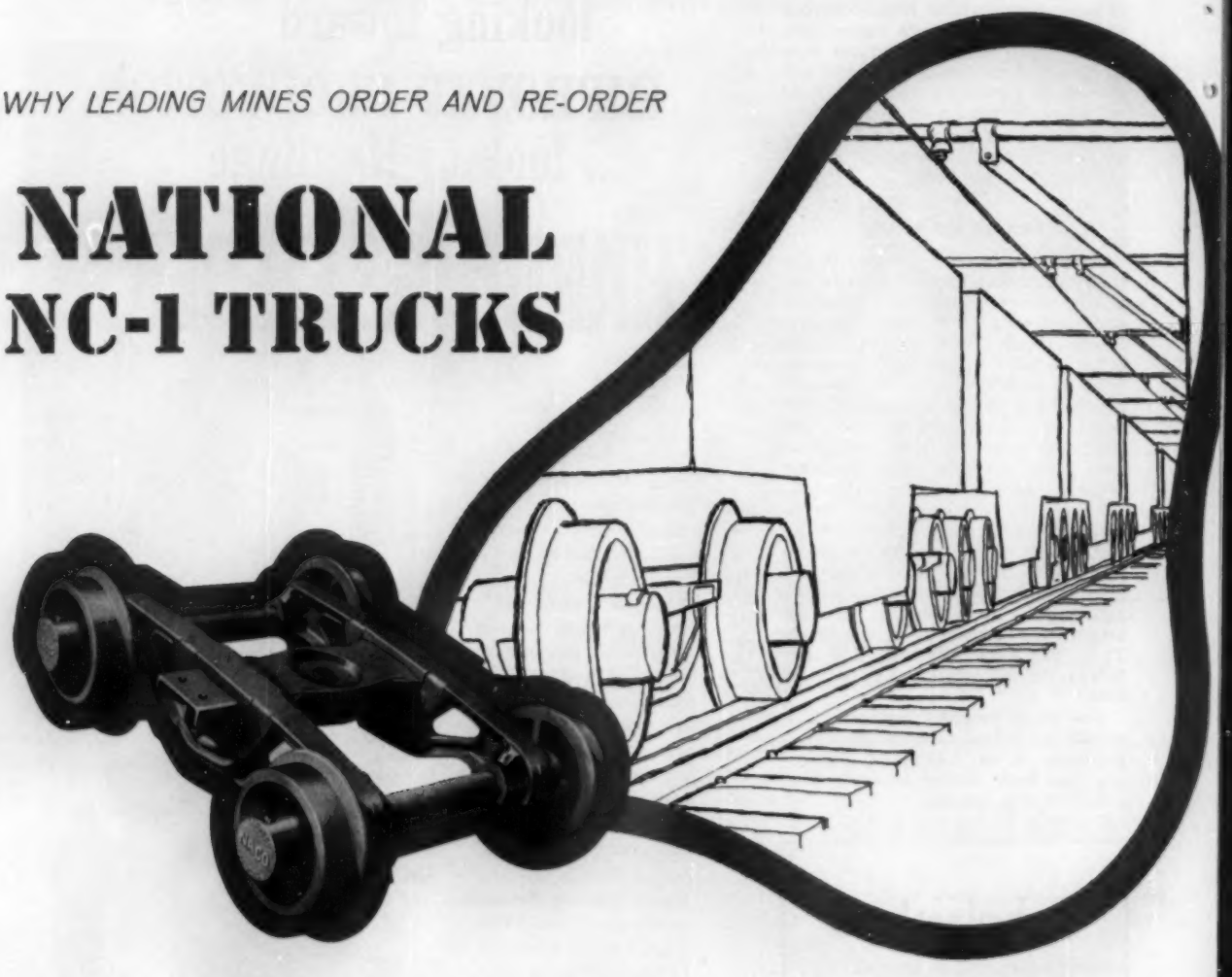
WHY LEADING MINES ORDER AND RE-ORDER

NATIONAL NC-1 TRUCKS



The reasons for the decided swing to National NC-1 Trucks are fundamentally two: they provide safety to personnel and equipment... they make money for mine operators. There are lots of technical reasons, too. Let our representatives tell you all about them.

A-1798A

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MALLEABLE AND STEEL
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Cleveland 6, Ohio

ROCK IN THE BOX

Mining & Exploration Division

Mining and Exploration Division Organization for 1961

Chairman
John G. Hall

Assistant Chairman
J. M. Ehrhorn

Vice Chairman Programs
Roger McConnel

Vice Chairman Publications
Ralph W. Marsden

Vice Chairman Membership
Hugh J. Leach

In accordance with Mining and Exploration Division Bylaws, the slate of officers nominated to serve beginning February 1961 was announced in *Rock in the Box* in July 1960. The nominations were as follows:
Since there were no other nominations these candidates will take office at the Annual Meeting in February 1961 in St. Louis.

Other Mining and Exploration Division offices yet to be filled are those of the five Unit Committee representing: 1) Underground Mining, 2) Open Pit Mining, 3) Geology, 4) Geophysics, and 5) Geochemistry. The Bylaws state: "It shall be the duty of the Unit Committee Chairman to canvass the members of his group and report to the Division Chairman the name of the member selected to succeed him as Unit Chairman" (at least two months in advance of the Annual Meeting). The Secretary and *Rock in the Box* Editor are named by the Division Chairman.

This year there will be an all-out effort to make all necessary appointments by December so that our new Division officers can be organized and prepared to function at the time they take office in February 1961. An appeal is therefore made to all present Unit Chairmen to submit the selection of their successors immediately. This will allow time for the new Unit Chairmen to appoint their Unit Committee members for Publications, Programs, and Membership. Those who accept M & E Division appointments should bear in mind that they accept a responsibility to their Society to perform certain functions in accord with specified schedules and be prepared to do this. We hope that by getting the ball rolling early this year we can avoid the rush and confusion that develops when deadline dates press near or go by.

The objective of the Mining and Exploration Division is to furnish a medium of cooperation between those directly engaged in metal mining and those engaged in the technologies of mineral exploration. To further the objective of cooperation toward a common goal and to advance these branches of the mining industry, this Division will promote and publish papers, arrange meetings and programs, and encourage education on any subject related to those phases of the industry. A strong and active slate of officers and Committee men are required to reach those objectives. Your cooperation and suggestions will be appreciated.

The Mining and Exploration Division Bylaws will be published on this page in January to afford you the opportunity to know your Division. Please read them carefully.—*John G. Hall, Incoming Division Chairman, 1961.*

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Around the Sections

Members of the Morenci Subsection enjoying a steak dinner at the Longfellow Inn. The 100 degree weather caused most of the members to doff their coats despite the air conditioning.

Officers and guests of the Morenci Subsection seated at head table left to right: Fred M. Winkler, R. J. McCarthy, Charles Sorvisto, K. N. Woollen, guest speaker, and Joseph Stanley.

• The **Morenci Subsection** (Arizona Section) opened the fall season with a meeting held September 13 at the Longfellow Inn. Because it was Primary Election Day the social hour traditionally held at 6:30 was advanced to 7:00 so that members would not have to content themselves with soft drinks. A steak dinner followed. After dinner K. N. Woollen, of General Electric Industrial Heating Dept. in Shelbyville, Ind., gave a talk, *Protecting Atmospheres and Furnace Equipment for the Copper Industry*, illustrated by colored slides showing generation and use of protective atmospheres in brazing and annealing processes. Forty persons (60 pct of the membership) attended the meeting. The membership of the Subsection is drawn from the various departments of the Morenci Branch of Phelps Dodge Corp. There are about 60 active members, but a number are on shiftwork and so cannot attend every meeting.

• At their October 19th meeting held in the Engineers' Club, members of the **San Francisco Section** heard C. J. Meyer of the University of California discuss copper in Africa. He has recently returned from an eight-month stay in Africa, where he investigated the geology of copper deposits.

• On October 13th the **El Paso Section** and the Women's Auxiliary honored AIME President Joseph L. Gillson and his wife at a cocktail and dinner meeting held in the Crystal Ballroom of the Hotel Cortez. The ladies were responsible for decorations at the head table. The 83 people attending heard Dr. Gillson give a talk on archeology in Mexico illustrated with colored slides. Clifford Hicks, Western Field Secretary, spoke briefly on this occasion.

• The **Ajo Subsection** (Arizona Section) met October 6 at the Copper Coffee Shop, where they heard Kenneth Dieth of the U.S. Air Force give an informative talk on the accomplishments already made in the field of electronics and its potential as related to industry.

• Following a social hour and dinner at the Hotel York, October 14, members of the **St. Louis Section** heard Charles Kunz, manager, Roll-Bond Div., Olin Mathieson Chemical Corp., talk on the Roll-Bond process, tracing the development from the beginning at Olin in 1950.

• The **Mid-Arkansas Section** met October 5 at Holiday Inn Motel in Hot Springs where they heard Robert J. Anderson of Battelle Memorial Institute speak on the general findings during the recent geophysical year. His talk was an enjoyable combination of wit and information.

• The **Central New Mexico Section** held its first dinner meeting of the fall season on September 17th in Grants. A talk and movie on large-hole drilling and a panel discussion on vanadium removal in the Grants milling operations were featured. During the business session, plans were made to hold the Uranium Symposium in Grants some time during May of 1961. H. A. Powers was cited for bringing in five new members.

• Nine Seniors from Bisbee and Douglas high schools who are interested in engineering careers were honor guests at a dinner meeting of the **Bisbee-Douglas Subsection** (Arizona Section) held at the Warren District Country Club October 11. B. J. Shell, chief engineer and general superintendent of the San Xavier Rock & Sand Co., Tuscon, presented an illustrated talk on

Officers and guests of Bisbee-Douglas Subsection from left: G. A. Dahlke, L. H. Ladd, B. J. Shell, E. F. Klein, and E. T. Torgersen.

Bisbee and Douglas high school seniors entertained by the Bisbee-Douglas Subsection are, standing, left: Bruce Mortinson, Charles Ables, Russell Griffith, John Hosfield and, seated: Jon Long, John Glenn, Tom Kenyon, Alfredo Maese, Armando Enriquez.

building with pre-stressed concrete to an audience of more than 65. The evening concluded with the showing of a film, *Building with Pre-Stressed Concrete*, presented by E. F. Klein, technical representative, Colorado Fuel & Iron Corp.

• The **Washington D. C. Section** held its first meeting of the season October 4 in the dining room of the Broadmoor Hotel. *Mechanization and Automation in Coal Mining* was the topic of discussion for the evening. Charles W. Merrill, chief, Division of Minerals, USBM, presided and introduced the first two films on coal mining: *News from the Coal Country* by North American Coal Corp. and *Powering America's Progress* by the National Coal Assn. T. Reed Scollon, chief, Division of Bituminous Coal, USBM, narrated a third film, *Hydraulic Coal Mining*, produced by the Bureau.

• Some 200 members and their wives attended the **Southeast Section** annual meeting held in Birmingham, Ala., September 30 to October 1, at the Dinkler-Tutwiler Hotel. Among the highlights of the two-day meeting were the welcoming address by Section Chairman Eugene P. Reed, manager of raw materials for U.S. Steel's Tennessee Coal & Iron Div.; the luncheon address by David C. Sayles, Chief of the Research Plans Branch at Redstone Arsenal; and the banquet speech by University of Alabama president Frank A. Rose.

In his speech Mr. Reed deplored the tendency to dwell on gloomier aspects of the times and ignore the more favorable. "By almost any yardstick you might care to apply, our economy is in better shape today than it has ever been," Reed declared. He added that the South is pacing the nation in industrial and economic gain. President Frank A. Rose made the point that most of our large corporations have laboratories and are carrying on research far more advanced than that of the colleges and universities. This places upon engineering schools greater responsibility for engaging in pure scholarship and for offering more courses that will give competence in a rapidly advancing science. David C. Sayles in his luncheon address considered the role of the professional engineer and the product of research in the U. S. Army Ordnance Missile Command.

High point of the technical sessions was the automation symposium. J. G. Creveling, assistant manager of raw materials, TCI, described the use of industrial television in underground iron ore mining operations; W. J. Biles, chief electrical engineer, The McNally Pittsburgh Mfg. Corp., discussed use of automated overhead trippers in loading railroad cars; and Walter Nielsen, superintendent of No. 5 blast furnace, U.S. Pipe & Foundry Co., compared hand-operated stove valves with automatic equipment in use on No. 5 blast furnace.

On the lighter side there was the trip to the Lewis Smith Dam, where the Alabama Power Co. provided lunch at the dam site. In the evening guests gathered for a pregame social, then saw Alabama beat Vanderbilt 21 to 0.

J. W. Nical, W. L. Dowdey, Mrs. Adolph Beck, Mrs. Dowdey and Miss Dowdey at fete.

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St. Louis, Missouri.....PLateau 2-2544
Reno, Nevada.....FAirview 9-0732
Spokane, Washington...WAlnut 4-2614
Alaska.....Contact Salt Lake City Office

Correction

The second paragraph of the item concerning Will Mitchell, Jr., appearing on page 1192 of the November issue of MINING ENGINEERING should read as follows:

Will Mitchell, Jr., was chairman of the Mining Branch Council when it became the Society of Mining Engineers of AIME. He has also been a director of the parent body, AIME, and was formerly on the Board of Directors of the Engineers Joint Council. He serves as Allis-Chalmers representative at the Industrial Research Institute.

Personals

R. E. KENDALL

V. N. BURNHART

H. E. ROBBINS

O. H. CHAVEZ

U. S. Borax & Chemical Corp. has announced the appointment of **R. E. Kendall** to the newly-created position of engineering manager at its mine and processing plants in Boron, Calif. Kendall was employed in 1954 as a planning engineer to make a feasibility study for proposed open pit mining at Boron. When open pit stripping started in 1956, he was named assistant mine superintendent, a position he held until his recent promotion.

Vincent N. Burnhart has been elected president of E. J. Longyear Co. to succeed Donald M. Davidson, who died recently. Burnhart, formerly vice president and general manager, joined the company in 1946. He was named general manager in April 1957 and became vice president in January 1958. A director of the Longyear Co. and of Canadian Longyear Ltd., he is also president of the Diamond Core Drill Manufacturers Assn.

Longyear directors also named four new vice presidents: **Rudolph C. Gebhardt,** mining; **Michael J. Gleason,** contract drilling; **Eugene Larson,** marketing; and **John F. Hoffmeister,** manufacturing. All four men are managers of the divisions of which they are now vice presidents.

According to a recent announcement from The Anaconda Co., **Harold E. Robbins,** formerly general superintendent of Andes Copper Mining Co., Potrerillos, Chile, has been promoted to the position of assistant manager. He will be in direct charge of the company's El Salvador copper mine and concentrator project.

Oscar H. Chávez, vice president of the Mexico Section, AIME, has been promoted to plant manager of the explosives plant of Cia. Mexicana de Explosivos, S.A., in Dinamita. He was formerly relations manager of Du Pont, S.A. de C.V. and Cia. Mexicana de Explosivos, S.A., a position he had held since 1958. He joined these Du Pont subsidiaries in 1956.

PROPOSAL FOR AIME MEMBERSHIP

I consider the following person to be qualified for membership and request that a membership kit be mailed to him:

Name of Prospective Member:

.....

Address

.....

.....

.....

Name of AIME Member:

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Address

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SME

CHANGE OF ADDRESS AND PERSONALS FORM

CHANGING YOUR ADDRESS? Don't forget to notify us six (6) weeks before you move, if possible, to insure uninterrupted receipt of your publications and correspondence. Please fill in the form below and send it to: J. F. Lynch, Asst. Treasurer AIME, 29 West 39th Street, New York 18, N. Y.

Name .....

Old Address .....

.....

.....

New Address .....

.....

.....

PERSONALS: Please list below your former company and title and your new title and company (or new work) for use in MINING ENGINEERING. (Copy deadline for personals items is six weeks before date of issue.)

Former Company .....

Former Title ..... Length of Time There .....

New Company .....

New Title ..... Date of Change .....

.....

Any recent activity that would be of interest to members:

.....

.....

.....

N. P. Zinni, former materials engineer with the Pennsylvania Department of Highways, has taken a job as sales engineer in the Asphalt Sales Div., Texaco Inc. His territory is Pennsylvania.

After four years as manager of the mining department of Société des Mines de Fer de Mauritanie, **Jacques F. Ledoux** left in January of this year to serve as U.N. mining adviser to the Uruguayan government. Following a four-month assignment, he returned to Paris to become export sales manager for B.B.T., engineers and builders in the coal, ore handling, and concentration field.

Ralph R. Swartz, a sales engineer, has been transferred from Spokane to Peekskill, N. Y., by Joy Mfg. Co.

James Solomon, formerly a junior industrial engineer with Kennecott Copper Corp., has taken a job as senior industrial engineer at the Las Vegas branch of Geo-Engineers Inc. He will also serve as branch manager.

James L. Harding, who had been teaching in the geology department of Mississippi Southern College, has enrolled at Texas A & M College, where he is studying for a Ph.D. in oceanography.

Jack Parker, formerly instructor in geology at Michigan College of Mining and Technology, has become an associate of R. L. Loofbourow, consultant in construction and underground mining, with an office in Minneapolis.

After 36 years with Dorr-Oliver Inc., **William E. Smith** retired this July 1st. At the time of his retirement he was general sales manager and administrator of international operations.

Giovanni Rossi, after working for five years as mill superintendent of a selective Pb-Zn-Cu-Fe sulfides plant for Montecatini S.A., has been transferred from Grosseto, Italy, to Trento, where he is mill superintendent in a fluorspar mine.

James S. K. McChesney has taken a job as chief mining engineer with Iron Mines Co. of Venezuela in San Felix. He has worked as a mining engineer for Marmoraton Mining Co. Ltd. in Ontario for the past seven years.

Following his retirement from Yuba Mfg. Co. after 35 years, **F. M. Blanchard** has started a consulting practice. He recently returned from an eight-month trip to Sierra Leone, West Africa, where he was in charge of shipping a placer gold dredge to Surinam, South America.

Don M. Coulter has left the Bureau of Indian Affairs in Muskogee, Okla., to work for Foor Engineering Co. in Spearman, Texas.

Thomas W. Schmucker has gone to work for White Pine Copper Co. following his graduation from Michigan College of Mining and Technology.

William C. Peters, formerly geologist with F. M. C. Mineral Development Dept., has become division geologist of the Nevada Mines Div., Kennecott Copper Corp., at Ruth, Nev.

Robert L. Edwards, formerly geologist with the fertilizer division of J. R. Simplot Co., has accepted a position as geologist with the mineral development division of Food Machinery & Chemical Corp.

D. A. Lauritsen, a research assistant at Oregon State College Engineering Experiment Station for two years, has become a sample preparation engineer in the exploration department of Ideal Cement Co. While acting as a consultant to Livingston Air Service, he designed and installed the automatic electric cargo system used on the helicopter featured on page 146 of the February issue of MINING ENGINEERING.

National Gypsum Co. has named **Charles W. Kelley, Jr.,** as superintendent of its block plant located in the Bronx, N.Y.

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F85 F-C

personals

continued

H. E. Wittenberg, Jr., has entered the graduate school of business administration of the University of California after a year as assistant research engineer with The Anaconda Co.

Upon completion of his two-year tour of duty with the U.S. Army, serving with geodetic survey units in Libya and Iran, **George E. Reeves** has taken a position as junior engineer with Heinrichs Geoexploration Co. in Tucson, Ariz.

Marvin Arthur Kunde, who had served as valuation engineer with the Internal Revenue Service for eight years, has become a tax engineer with Jones & Laughlin Steel Corp. He graduated this June from the University of Denver College of Law and was admitted to the bar in Colorado in October. He received his E.M. degree from the Colorado School of Mines in 1952.

Following his graduation from Michigan College of Mining and Technology, **Thomas A. Miché** has become an industrial engineer trainee at Jones & Laughlin Steel Corp.

Robert M. Birch has gone to work for Braden Copper Co. as planning foreman following his graduation from the University of Utah.

E. L. Corp has gone into business for himself as an electrical contractor. He formerly worked for Climax Molybdenum Co. as an industrial engineer.

J. K. Hill, formerly geologist with the High Country research team of the Otago Catchment Board, Dunedin, New Zealand, has moved to Canberra, Australia, where he is a geologist, Grade I, with the Bureau of Mineral Resources, Geology, and Geophysics. In his new capacity he has been engaged in engineering geology in connection with a thin arch dam to augment Canberra's water supply and has carried out lake edge mapping prior to the creation of an artificial lake dividing Canberra City.

Philip W. Simmons has recently transferred from the U. S. Bureau of Mines to the International Cooperation Administration following a two-year assignment as mineral advisor to the Indonesia Bureau of Mines under a working arrangement whereby the USBM supplies mineral technicians to ICA whenever needed. His present position with ICA is that of supervisory mining engineer in the Washington, D. C. office.

Henry P. Ehrlinger III has been promoted from assistant mill superintendent to mill superintendent and transferred from the Santa Barbara Unit of American Smelting & Refining Co. to the company's Charcas Unit.

J. H. LUCAS

P. W. McGANN

John H. Lucas has recently been promoted from quarry and crushing plant superintendent to assistant general superintendent for the Cushenbury plant, Permanente Cement Co., in Lucerne Valley, Calif.

Paul W. McGann, former chief economist for the U.S. Bureau of Mines, has joined the Washington, D. C. staff of Arthur D. Little Inc., international industrial research and consulting company. As senior economist for the company, he will analyze economic problems involved in supply, demand, cost, investment, and trade aspects of mineral resource production.

Following completion of work for a Master of Science degree in the mining department of the University of Melbourne, **T. W. Healy** has come to the U.S. to take a position in the graduate school of chemistry at Columbia University.

L. M. Robinson, formerly general manager for Fluoresqueda S.A. in Esqueda, Mexico, has taken a job as mining engineer with AEC in Grand Junction, Colo.

Samuel S. Stuard has become district sales manager for T. B. Wood's Sons Co. He was field sales engineer for the company before his promotion.

B. B. Abrams, formerly commanding officer of the Rossford Ordnance Depot, Toledo, has been transferred to Washington, D.C., to serve in the Office of the Chief of Ordnance as chief of the Repair Parts Office. Before leaving for his new assignment, he was presented with the key to the city by Toledo's mayor and a Community Service Award by the Chamber of Commerce. He also had been elected to the Board of Directors of the Toledo Chapter of American Institute of Industrial Engineers.

Derek J. Barratt has interrupted his studies at the Royal School of Mines, London, to work for a year with McIntyre Porcupine Mines Ltd. in Schumacher, Ont., Canada.

Alonzo R. Kieffer III, on military leave of absence from Allis-Chalmers Mfg. Co., is assistant resident officer in charge of construction at the U.S. Naval Auxiliary Air Station in New Iberia, La.

R. W. JENKINS

C. E. HANEY

According to a recent announcement from the company **Ray Jenkins,** consultant in mining and construction, has joined the staff of The Ralph M. Parson Co. in Los Angeles. He was formerly general manager of Anderson Development Corp. in Grants, N. M.

Charles E. Haney has been named a vice president of Electric Steel Foundry Co. He will continue as works manager in the Foundry Production departments, a position he has held since 1954.

Upon graduating from the University of Minnesota School of Mines and Metallurgy in June, **Stanley C. Richardson** joined the Utah Copper Div. of Kennecott Copper Corp. as a management trainee.

Charles L. Hamilton has accepted a position as an instructor of geology at Newark College of Arts and Science, Rutgers University. While a graduate student at Virginia Polytechnic Institute, he mapped part of the Peaks of Otter Quadrangle, northeast of Roanoke, in preparing his Ph.D. dissertation.

After five years as senior geologist in the Bear Creek Mining Co. Operating Properties Div., Bingham, Utah, **Fred H. Howell** has become chief geologist for Duval Sulphur & Potash Co. and has moved to 7015 Redbud Road, Tucson, Ariz.

Mark L. Ward, formerly mining geologist with New Idria Mining & Chemical Co., has become chief mine engineer at the Camp Bird mine of Camp Bird Colorado Inc.

T. D. Short, formerly blasting supervisor, N. Y. Ore Div., Jones & Laughlin Steel Corp., has joined the explosives sales-service department of Hercules Powder Co. Before being assigned a sales district he is undergoing a six-month company training program that will take him to various sections of the country to observe all types of mining and construction locations.

After two years as geologist with Utah Construction & Mining Co., **H. J. Recktenwald** has joined the U.S. Navy as a student aviator. He is presently stationed at Kingsville, Texas.

Murray C. Gardner has taken a position as field geologist with the Land Dept., Southern Pacific Co., where he is participating in a mineral resources survey and a geologic mapping program of all lands owned by the company. Prior to undertaking this assignment, he was a geology instructor at the University of Arizona.

Edwin F. Atkinson has joined Le Roi Div., Westinghouse Air Brake Co., as a special representative. He had been a research engineer for Climax Molybdenum Co. for four years before making this change.

Sam D. Broadhurst, formerly assistant state geologist of North Carolina, has taken a job as industrial geologist with Norfolk & Western Ry. Co. in Roanoke, Va.

After three years as city engineer of Coeur d'Alene, Idaho, **Lloyd D. Brownson** has moved to Astoria, Ore, where he has accepted the position of public works director.

Ross W. Smith has accepted an appointment as assistant professor of metallurgy at the South Dakota School of Mines and Technology. For the past two years he was project engineer at the Colorado School of Mines Research Foundation.

Chester F. Norstrom, Jr., formerly assistant research engineer, Colorado Fuel & Iron Corp. at Cedar City, Utah, has moved to Libertyville, Ill., to attend Northwestern University's graduate school of business administration in Chicago.

Joy Mfg. Co. recently announced the appointment of **Stephen Laskevich, Jr.,** as district manager of its Knoxville, Tenn. district sales office. He has been with the company since 1946.

John E. Frost has returned from the Philippines, where he served as chief geologist for Philippine Iron Mines for the past six and a half years, to enroll at Stanford University for further graduate studies to complete requirements for a Ph.D. degree.

William B. Agocs, formerly director of geology and geophysics for Aero Service Corp. and affiliates, recently established offices in Philadelphia as a natural resources evaluation consultant (domestic and foreign) utilizing geological-geophysical survey procedures.

Following completion of requirements for his Ph.D. in physics at the University of Toronto, **David W. Strangway** has taken a position as research geophysicist with Bear Creek Mining Co. in Awada, Colo.

Robert D. Greer has moved from Franklin Heights, Pa., to Columbus, Ohio, to take a job in the sales department of Jeffrey Mfg. Co. He was formerly pricing analyst for another manufacturing company in the same field.

Calumet & Hecla Inc. recently transferred **George F. McKereghan** from the Uranium Div., Grants, N. M., where he had been acting as mine manager, to the Calumet Div., Ahmeek, Mich., where he is employed as an administrative engineer.

G. W. Walkey, formerly production manager for Stanrock Uranium Mine, Elliot Lake, Ont., has been appointed mine manager for Kam Kotia Porcupine Mines at Timmins, Ont.

William S. Ransom has begun his professional career with a job at U.S. Gypsum Co., East Chicago, Ind. He is a recent graduate of the Colorado School of Mines.

Following his graduation from the Missouri School of Mines this summer, **Ernesto L. Ahnert** returned to his native Mexico and has recently accepted a job as mining engineer with San Francisco Mines of Mexico Ltd. at San Francisco del Oro.

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personals

continued

R. E. SHREVE

G. H. BRYANT

H. D. WEBB

A. E. LAMM

Walter H. Voskuil has accepted an appointment as visiting professor of mineral economics at the Mackay School of Mines following his retirement as principal mineral economist with the Illinois State Geological Survey. He had been associated with the Survey for 29 years.

Hans N. Schreiber, geologist with American Zinc, Lead & Smelting Co., has been transferred to Hanover, N. M., in a joint venture with Peru Mining Co. to reopen its Kearney mine in the Santa Rita district. His present work includes development of known reserves and drilling for additional reserves.

James F. Donovan has gone to work for U.S. Steel Corp. at Pittsburg, Calif.

Upon graduation from the University of Nevada, **Morris E. Friberg** joined Phillips 66 Petroleum Co. as a junior mine engineer. He is assisting in the development of one of the company's uranium properties in Grants, N. M.

C. Gordon Benson has been promoted from manager—product service, Portable Appliance Dept., General Electric Co., to West Coast regional service manager, Housewares and Commercial Equipment Div.

After 31 years in Rhodesia as a consulting geologist and an employe of Anglo American Corp. of South Africa Ltd., **T. D. Guernsey** has recently returned to Canada, taking up residence in British Columbia, where he and his wife are slowly becoming acclimatized to their new surroundings.

Guy B. Hunner has retired to Deland, Fla., after 38 years with M. A. Hanna Co. For the past 15 years he has been on the Cuyuna Range, where he was employed as general superintendent at the time of his retirement.

Walter E. Conrad has taken employment with U. S. Gypsum Co. at Plaster City, Calif.

Philip De F. Bleser, formerly supervisor of production for Orinoco Mining Co., has joined Eastern Magnesia Talc Co. as chief engineer.

The president of the companion companies, Susquehanna - Western Inc. and Mines Development Inc., recently announced three executive-level personnel advancements. At Susquehanna-Western, which owns and operates a uranium mill and sulfuric acid manufacturing plant at Riverton, Wyo., **G. H. Bryant,** formerly mill superintendent of Riverton facilities, has been named manager of the metallurgical division. **Richard E. Shreve** succeeds him as mill superintendent. He had been superintendent of the Gunnison Mining Co. uranium mill for more than two years. At Edgemont, S. D., **Hal D. Webb** has been named mill manager of the facilities of Mines Development Inc., which include both a uranium ore processing mill and a vanadium recovery plant. Prior to his promotion Mr. Webb was mill superintendent at Edgemont.

Arnold E. Lamm, formerly president and a principal owner of Sunnyhill Coal Co., was recently named president of The Pittsburg & Midway Coal Mining Co. by the Board of Directors to fill the vacancy created by the resignation of Edwin R. Phelps.

Following graduation from the Colorado School of Mines this summer, **M. L. West, Jr.,** has gone to work for Aluminum Co. of America at Rockdale, Texas.

James J. Norton has been transferred from the Denver office of the U. S. Geological Survey to the Washington, D. C. office, where he has been assigned to the Light Metals and Industrial Minerals Branch.

E. J. Perry has joined Asbestos Corp. Ltd. as assistant to the mining superintendent at the King Beaver mine in Quebec. After leaving Maritimes Mining Corp. Ltd., Tilt Cove, Newfoundland, where he was assistant chief engineer, he spent five weeks in England and Switzerland.

Following a pleasure trip around the world, **Michael V. Anthony** has taken a position as research assistant in the Soil Engineering Div., Civil and Sanitary Engineering Dept., Massachusetts Institute of Technology. He was formerly a project engineer at Engineer Research and Develcpment Laboratories at Ft. Belvoir, Va.

The president of American Zinc, Lead & Smelting Co. recently announced the promotion of **John P. Lacke,** former general superintendent of the Vinegar Hill Div. operations, to the position of resident manager. **Paul J. Mills,** who served as assistant superintendent during the past year, has been promoted to mine superintendent.

S. S. Thurmond, Jr., has been appointed senior geologist for Zontelli Bros. and has been transferred from New Mexico, where he has been in charge of uranium exploration since joining the company in 1955, to Moscow, Idaho, where he will be in charge of exploration activities in the Northwest. One of the projects is a diamond drill exploration program near Potlatch, Idaho, to investigate a magnetite iron ore prospect. **Martin Torgerson** is handling the drilling program under Mr. Thurmond's direction.

Another change in executive personnel is the transfer of **Steve R. Blanich** from the Dakota Aggregate Co., a Zontelli subsidiary, to the parent company's headquarters in Ironton, Minn., where he will assume the position of senior mining engineer. Prior to his transfer, Mr. Blanich was plant superintendent in charge of the Medina, N. D. operations.

Fred Megerth has entered the employ of General Electric Corp., San Jose, Calif.

Ted D. Haley has taken a job as a salesman of blasting materials for Spencer Chemical Co., working out of Birmingham. He was formerly superintendent of a coal mine for the Lone Star Steel Co. of Dallas.

David P. King, geological engineer with the U.S. Atomic Energy Commission, has been transferred from the Casper Branch, Production Evaluation Div., to the Spokane Section of the Salt Lake Branch.

Walter H. Johnson has begun his professional career with a job at the Dawn Mining Co., Ford, Wash.

Walter D. Steinmann, engineer assistant with U.S. Gypsum Co., has been transferred from the Sweetwater plant to the Shoals plant in Shoals, Ind.

Douglas M. Shaw has moved to Melbourne, Australia, to become manager of engineering for Utah Australia Ltd. For the past five years he has been associated with Utah Construction & Mining Co. at Palo Alto, Calif. He was chief project engineer at the time he left.

Obituaries

Glen L. Bateman (Member 1927) died early this year following an operation. He was 56 at the time of his death. Although a U.S. citizen, Mr. Bateman was born in Johannesburg and in 1926 returned to South Africa, where he continued to live until his death. He was educated in the U.S., attending Phillips Andover and the Massachusetts Institute of Technology. After graduation he spent one year with the Dorr Co. Inc. of New York in connection with erection and testing work. This was followed by three months with the Oliver United Filters Inc. of Oakland, Calif., working in Hawaii on sugar filtration. Upon his return to Johannesburg he became associated with the firm of Edward L. Bateman (Pty.) Ltd. on laboratory and field work connected with metallurgical and chemical installations of Dorr and Oliver. Later he worked as sales engineer for the firm and became a director.

Harry K. Ihrig (Member 1937), vice president in charge of research for Allis-Chalmers Mfg. Co., died of a heart attack August 22. He had been with the company since 1950. Before that he had been vice president and director of laboratories for the Globe Steel Tubes Co. for 17 years. An inventor and researcher, he held 22 patents. One of his best known inventions was a process to make ordinary steel resistant to corrosion and acid. Mr. Ihrig was born in Appleton, Wis., in 1898 and spent most of his professional career in the Milwaukee area. He attended Carleton college in Minnesota, received his B.S. degree from the University of North Dakota in 1919 and his Master's degree from there in 1920. He received his Ph.D. from the University of California in 1923.

Edward S. O'Connor (Member 1912), president-manager of Book Cliff Coal Co., died May 25, 1960, in a Billings, Mont. hospital, where he was taken after becoming ill before boarding a plane back to Salt Lake City. He was born Jan. 1, 1883, in St. Paul and graduated from the School of Mines, University of Minnesota in 1906. He came to Utah in 1928 to work at iron mines near Cedar City for Columbia Steel Co. In 1938, when the company became Columbia-Geneva Div. of U.S. Steel Corp., Mr. O'Connor became superintendent of mines in Carbon County. After retiring in 1949, he purchased Book Cliff Coal Co.

Hubert W. Schranz (Member 1954) died April 26, 1960, in Clausthal-Zellerfeld, Germany. At the time of his death he was professor and director of mineral dressing at the School of Mines in Clausthal. He was born in Magdeburg, Germany, on June 14, 1893, and attended both the Clausthal Mining Academy and the Freiberg Mining Academy. He began his career during World War I as manager of the mine and ore dressing plant of the War Raw Materials Dept. at Zinnwald. From 1933 to 1937 he served as consulting engineer to the Iranian government in Teheran. In 1950 he became a member of the staff of the School of Mines in Clausthal.

John G. Bachner (Member 1955) died in Anchorage, Alaska, in his 67th year. He was born in Germany, later coming to the U.S. and becoming a citizen. He had been owner-partner of Kenai Chrome Co. in Anchorage since 1952.

George A. Warner (Member 1922) died June 26 in Albuquerque, N. M. at the age of 61. A graduate of the New Mexico Institute of Mining and Technology, he had been associated with Shattuck Denn Mining Corp. in New Mexico since 1940. His early professional activities, from 1926 to 1940, were carried on in Arizona for successively Phelps Dodge Corp., Cochise County, and later for the U.S. Army. Mr. Warner was born in

(Continued on page 1292)

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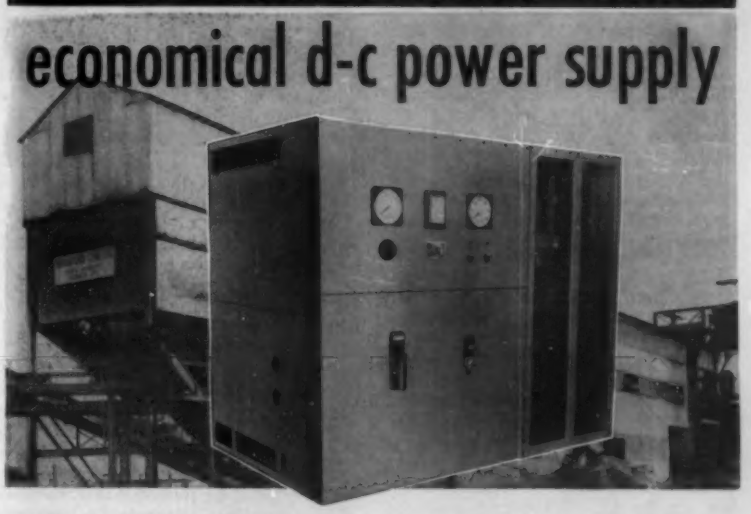

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Obituaries

(Continued from page 1291)

Somerville, Mass., where he spent his school days. He first came to the Southwest when he enrolled in the New Mexico School of Mines.

Forest H. Neely (Member 1956) died May 9 at Martinsburg, W. Va. He was born August 30, 1895, in Jane Lew, W. Va., and received his professional education at the West Virginia University School of Mines. A great deal of his work was with crushing machinery but he had had a career full of variety, including chemical plant design, consulting work, specification writing, mining engineering, mechanical engineering in power plants, and construction and evaluation engineering.

E. H. Dickenson (Member 1914) died at his home in New York City on June 8, following a brief illness. Born in Nova Scotia in 1886, he became a U.S. citizen in 1928. He was educated at Laval University Montreal, and Columbia University School of Mines. He received an M.A. degree from Columbia in 1959 and was studying for a Ph.D. at the time of his death. Mr. Dickenson had been associated with Ingersoll-Rand Co. for 35 years before he retired about a year and a half ago. Just a week before his death, Ingersoll-Rand published his book *Rock Drill Data*. Before joining Ingersoll-Rand he had been with many other concerns in the metallurgical and mining fields; his work with Tata Iron & Steel Co. of Calcutta took him to India from 1916 to 1921. In addition to his mining activities, Mr. Dickenson was a mathematician and had taught mathematics at the University of Pennsylvania and Drexel Institute in Philadelphia.

George H. Gilman (Member 1917) died at his home in Belmont, Mass., on June 8 at the age of 78. An expert on drilling, he began his career with Canadian Rand Drill Co. as an apprentice pattern maker. Six months later he was selected by the company to take a special course in engineering, shop practice, and the sale and application of mining machinery. While working as a master mechanic for E. L. Smith Co., Barre, Vt., from 1904 to 1905, he developed a percussive drilling machine that established a world record for performance. In 1919 he started his own firm, the Gilman Mfg. Co., which produced a complete line of rotating percussive rock drills and drill steel shop machinery. In 1930 his firm was merged with the Worthington Pump & Machinery Corp. Mr. Gilman remained on in a consulting capacity, executing special assignments on such major construction projects as the Colorado River Aqueduct, Hoover Dam, Grand Coulee Dam, Delaware Aqueduct, and the tunnels of the Pennsylvania turnpike. From 1939 he engaged in private consulting practice, with the exception of two years as works manager for A. S. Campbell Co., in the production of war material. He was a Canadian by birth but had lived in Belmont for 40 years.

Franklin E. Johnson (Member 1939) was killed instantly in an auto accident on March 15 in Carlsbad, N.M. A native of Wisconsin, he attended the University of Wisconsin for two years, then transferred to the University of California, from which he received a B.S. in mining engineering in 1924. Upon graduation he went to work for Federal Mining & Smelting Co. at the Morning mine, starting as an underground miner and working up to a position as mine engineer. Following some prospecting and exploration in the West, he moved in 1934 to the Philippines, where he was continuing his career at the time he joined AIME in 1939. Over the past 10 years he has been with U.S. Potash Co. in Carlsbad. He was 59.

Horace Moses (Legion of Honor Member 1901), former general manager of the Chino Mines Div. of Kennecott Copper Corp., died June 20 in St. Vincent's Hospital at Santa Fe, N.M. He was 80. One of New Mexico's outstanding pioneers in the mining industry, Mr. Moses was born in St. Louis but was brought to New Mexico as an infant. He was educated in the public schools of Silver City and attended Silver City Normal School for a couple of years. In 1900 he went to work for the old Santa Rita Mining Co. where he stayed for three years. The next six years he spent working in mining operations in Montana, Utah, Arizona, and Mexico. He returned to Santa Rita in 1909, the year the Chino Copper Co. was incorporated, to begin mass mining operations in the old mining area. In 1917 Chino transferred him to Gallup to take charge of its subsidiary, the Gallup American Coal Co. He remained there until 1938, when he was recalled to Santa Rita to become general manager of the Chino operations. Under his direction the division was transformed into a much larger and more modern property. During his administration the mine was converted from steam to electric power, the smelter and "fire" refinery were built at Hurley, a lime quarry was begun, and an underground Pb-Zn mine was developed. In 1947 Mr. Moses retired and moved to Santa Fe, where he made his home until his death.

Ira L. Wright (Member 1914) died June 16 in an El Paso, Texas hospital at the age of 76. He had been in ill health for the past year. Mr. Wright played a principal part in the development and operation of mining properties in southwest New Mexico for more than 40 years. He began his mining career with Chino Copper Co. and after several years left to start operations on his own. Leasing a long dormant Au-Ag producer at Pinos Altos he opened up a rich orebody and with this stake was able to expand his mining activities. For 10 years prior to World War II he reopened and put into profitable production the early-day bonanza Au-Ag Fanny mine at Mogollon for the Black Hawk Co. Mr. Wright was born in Hughesville, Mo., and was a graduate of the Missouri School of Mines.

J. Murray Riddell (Member 1917), professor emeritus of mining engineering at Michigan College of Mining and Technology, died July 13 at the age of 72 at his home in Houghton. He retired from the college staff in 1956. He was born in Pasadena, Calif., later moving to Chicago, where he attended Lewis Institute. He received his degree in mining engineering from Michigan College of Mining and Technology.

During his early career, Riddell held positions of responsibility in the iron mining industry of northern Michigan, Wisconsin, and Minnesota. In the late 1920's he served as superintendent of Kentucky coal mines for Corrigan, McKinney Steel Co. From 1930 to 1932 he served as chief engineer with a group of engineers working for Oglebay Norton & Co.

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in Russia. Later he served as assistant manager of Northern Ore Mines for Republic Steel Corp. and from 1940 to 1945 as manager of the Mining Division, E. J. Longyear Co. Mr. Riddell was a consultant in shaft sinking and patentee of the Riddell shaft mucker.

Gerald R. Swenson (Member 1955) died July 22 at Redstone Arsenal, Ala. He was born in Garfield, Minn., March 26, 1936. He graduated from the South Dakota School of Mines in 1958.

Phillip C. Emrath (Member 1948) died in Lexington, Ky., on the 4th of July. He was born in Golconda, Ill., on the first day of the twentieth century. A graduate of the University of Kentucky, he returned in 1928 to take his E.M. degree and to join the faculty. He continued his academic career until 1943, when he returned to the active mining field. While manager of Alco Lead Corp. he began a consulting practice and in 1947 began to devote his full time to it.

Necrology

Date Elected	Name	Date of Death
1933	Donald M. Davidson	Sept. 15, 1960
1901	K. F. Goransson (Legion of Honor)	Unknown
1898	J. McC. Henderson (Legion of Honor)	Aug. 2, 1960
1916	William W. Logan	Sept. 6, 1960
1920	Robert C. Moffitt	Sept. 21, 1960
1925	Rollin A. Pallanch	Sept. 29, 1960
1951	E. H. Stevens	Unknown

Membership

Proposed for Membership
Society of Mining Engineers of AIME

Total AIME membership on October 31, 1960, was 34,502; in addition 2,704 Student Members were enrolled.

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The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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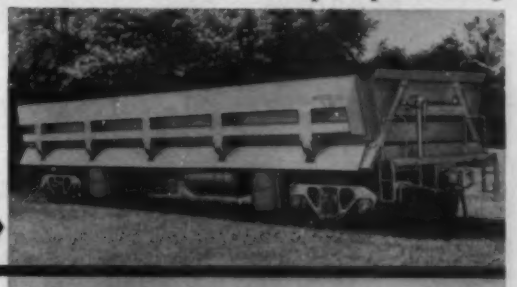

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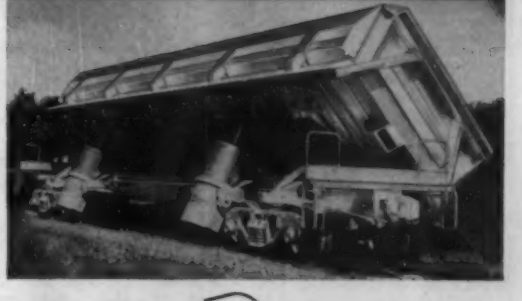

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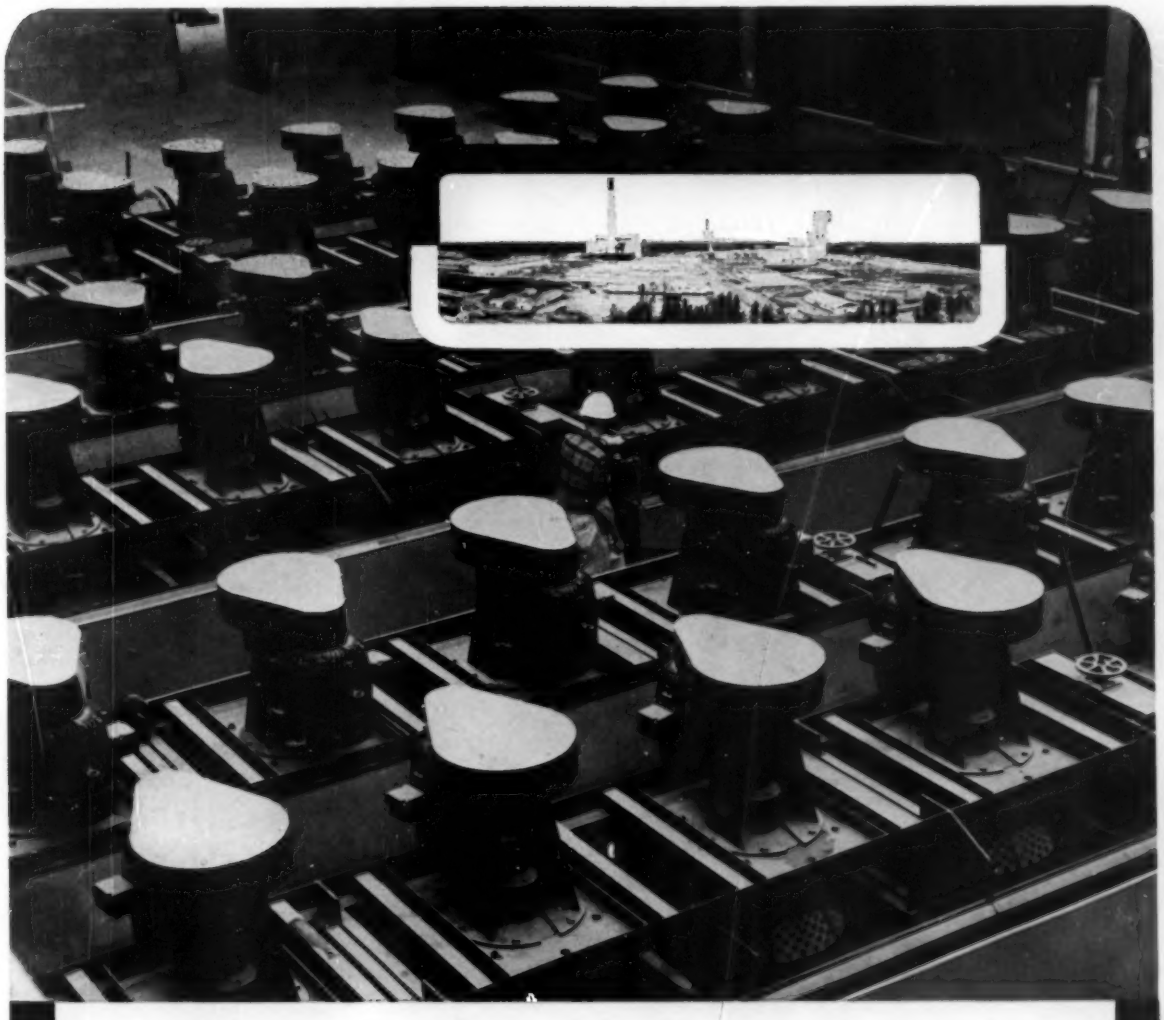

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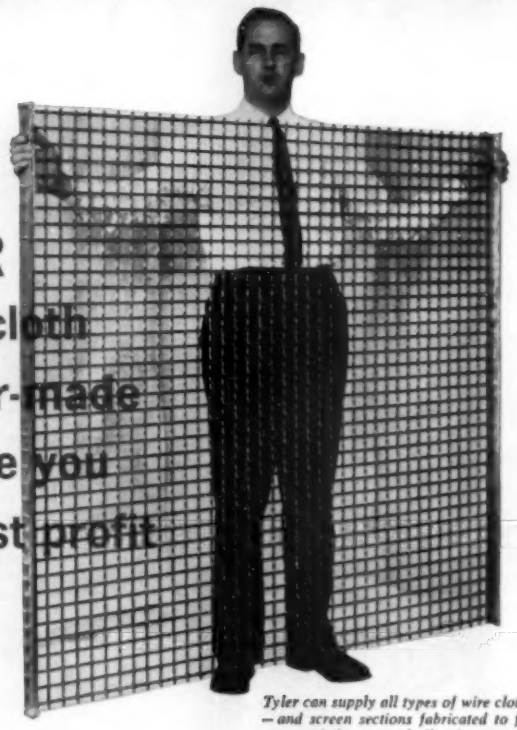

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